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ISIS

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:: of Science and Civilization ::
Quarterly Organ of the History of Science Society and of the International Committee of the History of Science.

SUMMARY
of No. 55 (Vol. XIX, 1)
(320 p.)

G. SARTON. — Preface to the Nineteenth Volume of *Isis* . . . 6
Ninth annual report of the Corresponding Secretary and Treasurer of the H. S. S. for the year 1932 11
Isis' Accounts for 1931 *and* 1932 13
Section of the History of Science of the Carnegie Institution (14th annual report, July 1, 1931 *to June* 30, 1932 . . . 15

Main Articles (7)

S. H. THOMSON *(Oxford)*. — The text of GROSSETESTE's *De Cometis* 19
C. CAMDEN, Jr. *(Houston, Texas)*. — Astrology in SHAKESPEARE's day 26
A. K. COOMARASWAMY *(Boston, Mass.)*. — On translation : Māyā, Deva, Tapas 74
D. J. STRUIK *(Cambridge, Mass.)*. — Outline of a history of differential geometry (I) 92
G. WINDRED *(Bedford)*. — The history of mathematical time (I) 121
B. C. PATTERSON *(Clinton, N. Y.)*. — The origins of the geometric principle of inversion 154
H. P. LATTIN *(Columbus, Ohio)*. — The origin of our present system of notation according to the theories of NICHOLAS BUBNOV 181

650740

Notes and Correspondance (5)

Annual Meeting of the American Council of Learned Societies (1932) 195
Obituaries: CARL HORBER (1882-1931) — Mrs M. W. WOWLES (1883-1932) 197
Miscellanea: The 50th anniversary of KOCH's discovery of the tubercle bacillus. — Prix Binoux 1932 200

Reviews (21)

Xth Century. al-Fārābī. — Iḥṣa' al-'ulūm; Arabic text with Arabic preface and notes by U. M. AMIN. Cairo, AL-KHĀNJĪ, 1931 (G. SARTON) . . 201
XVIIth Century. VILLAMIL, R. DE. — NEWTON. London, KNOX, 1931 (J. PELSENEER) 203
FULTON, J. F. — A bibliography of the Honourable ROBERT BOYLE. Oxford University Press, 1932 (T. L. DAVIS) 204
XVIIIth Century. CARRÉ, J. R. — La philosophie de FONTENELLE ou le sourire de la raison. Paris, ALCAN, 1932 (H. METZGER) 205
XXth Century. The life and work of Professor W. H. PERKIN, jr. London, The Chemical Society, 1932 (T. L. DAVIS) 207
Israel. FELDMAN, W. M. — Rabbinical mathematics and astronomy. London, CAILINGOLD, 1931 (S. GANDZ) 208
Philosophy of Science. BRUNSCHVICG, L. — De la connaissance de soi. Paris, ALCAN, 1931 (P. BRUNET) . . 212
Logic. BURKE, J. B. — The emergence of life. Oxford University Press, 1931 (H. T. DAVIS) 214
PEIRCE, C. S. — The collected papers of C. S. PEIRCE. Vol. I. Harvard University Press, 1931 (H. T. DAVIS); Vol. II. (W. V. QUINE) 217
Mathematics. LORIA, G. — Il passato e il presente delle principali teorie geometriche. Padua, CEDAM, 1931 (R. C. ARCHIBALD) 229
LORIA, G. — Storia delle matematiche, vol. II, sec. XVI e XVII. Torino, STEN, 1931 (R. C. ARCHIBALD) 231
VERA, F. — Historia de la matemática en

España. I. Tempos primitivos hasta el siglo XIII. II. Los precursores del renacimiento siglos XIII, XIV y XV. Madrid, SUÁREZ, 1929 & 1931 (R. C. ARCHIBALD) 232

Chemistry. BACHELARD, G. — Le pluralisme cohérent de la chimie moderne. Paris, VRIN, 1932 (H. METZGER) 233

Geography. MARGUET, F. — Histoire de la navigation du XV^e^ au XX^e^ siècle. Paris, Soc. d'éd. géogr., marit. et coloniales, 1931 (L. SAPIN) . . . 235

HERMANNSSON, H. — The cartography of Iceland. Oxford University Press; 1931 (S. EINARSSON) 237

History of Morals. BERGSON, H. Les deux sources de la morale et de la religion. Paris, ALCAN, 1932 (L. GUINET) 240

BAYET, A. — La morale et la science. Paris, Presses universitaires, 1931 (J. PELSENEER). 241

Medicine. PACKARD, F. R. — History of medicine in the United States. New York, HOEBER, 1931 (C. D. LEAKE) 245

STONE, E. — Medicine among the American Indians. New York, HOEBER, 1932 (C. D. LEAKE) 247

JEANSELME, E. — Histoire de la syphilis. Paris, DOIN, 1931 (C. D. LEAKE) 249

Thirty-fifth Critical Bibliography of the History and Philosophy of Science and of the History of Civilization (to August 1932) (350 items contributed by 18 scholars) 253

Preface to the Nineteenth Volume of Isis

At the time of beginning a new volume of our journal a retrospective view may be permitted. Indeed it is worth while to stop our effort for a few moments and to consider what has been done—this is easy enough—and what remains to be done —and this is more difficult.

The stately row of the volumes already published contains by far the largest collection of papers on the History and Philosophy of Science ever put together anywhere. There are at least three other collections which are still larger (though *Isis* is rapidly overtaking them), but far less comprehensive: Prince BONCOMPAGNI's *Bollettino* was devoted to the mathematical sciences; our contemporary, the Dutch *Janus*, deals chiefly with medicine; the German *Mitteilungen* are almost exclusively bibliographical. *Isis* does not only include a very large collection of original papers on almost every aspect of our studies, but also an immense amount of bibliographical information arranged in such an order that reference to it is as easy as it is profitable, and finally an iconographical corpus of increasing wealth (1). And yet the Editor is so deeply impressed by the shortcomings of his work that he prefers not to boast of past achievements except in so far as this may give our contributors and readers, and the students of the History of Science all over the world, more courage and a renewed confidence in the work which remains to be accomplished.

For we can not say it too loudly, however great our effort may seem as compared with previous ones, it is very small indeed as compared with the immense task which is still untouched. We are like travellers who started to conquer a lofty mountain

(1) This statement could easily be proved by a statistical summary which the writer, being far away from his books, is unable to submit at present, but which will be published in a forthcoming number of *Isis*.

XUM

but are still struggling in the foothills. It is too early to triumph, and the whole of our energy is but too little for the labor in prospect. Our eighteen bulky volumes, so full of facts and ideas, make a brave show to be sure, but the day is too young for reminiscences. When they shall be a fifty or a hundred it will be more permissible perhaps to indulge in retrospection and pride of effort, but for the present it is better to devote our attention to our shortcomings and to consider means of correcting them.

***

To begin with, if one takes into account the complexity of our public and of its needs, it is clear that the contents of *Isis* are not sufficiently varied. The remedy to this is easy enough and the Editor would have applied it a long time ago but for financial difficulties. It is well known that even as it is the publication of *Isis* is a heavy financial burden upon his shoulders in spite of the generous help given by the History of Science Society and by a few faithful friends. To put it in the briefest form, out of the first eighteen volumes, perhaps as much as half of them and perhaps more, have been *given* by him outright to the subscribers. The simple remedy would be to suppress from *Isis* all the longer papers (say, those covering more than thirty pages) and to publish these papers separately in another series. It is clear for example that when we publish a long memoir on Chinese astrology or Greek geometry, we give profit and pleasure to a few of our readers—very few—but we risk to annoy or displease all the others. I hope to be able eventually to publish the longer memoirs in a new series—each memoir forming an independent number of it complete in itself. This series might be entitled *Osiris* to recall its relationship to *Isis*. Members of the History of Science Society would not receive the numbers of *Osiris* free of charge, but they could obtain them at a reduced price, each member buying only those of special interest to him. In this simple fashion the capacity and diversity of *Isis*, its richness of contents from a general point of view, would be considerably increased. It is to be hoped that this long deferred plan may finally be accomplished with the assistance of the Revolving Book Fund of our Society.

XUM

In the second place, though our illustrations have increased in quantity and quality—much faster indeed than our ordinary income justified it,—they are still very insufficient. *Isis* should contain a gallery of portraits and facsimiles of such abundance, variety, and beauty, that it would appeal not only to professional historians of science (very few in number, alas) but also to scientists and historians in general, and even to book collectors and dilettanti.

In the third place, in spite of every editorial effort, the biological sciences and even the physical sciences have not yet been as well represented as they deserved. For the biological papers this may be partly explained by the existence of many medico-historical journals, though even those journals contain but few of them.

In the fourth place, it should be more possible for the Editor to offer acceptable royalties to at least some of the contributors. Most scholars are poor and their time is valuable. It would be only fair if it were possible to offer them a compensation, too small to encourage greed, but large enough to stimulate their effort and give some economic justification to it. Such compensations should be particularly desirable in the case of papers written at the Editor's own initiative, for example, obituaries, reports, and reviews, or in the case of papers composed to improve the intellectual balance of the journal.

⁂

I am writing this preface in view of one of the most beautiful and touching landscapes of the world,—the gentle hills which surround the old city, the medīna, of Fez. In the course of the last twelve months it has been my privilege to visit a great part of the Muslim world—practically all the Muslim countries of to-day and of the past which surround the Mediterranean Sea,—and Fez is the most perfect Muslim city I have seen thus far. Thanks to LYAUTEY's foresight and genius, it has remained almost inviolate. In spite of telephones and phonographs, Fez al-Bali is still an exceedingly homogeneous Muslim city, one of the most sacred cities of Islām, one which can not but appeal deeply to the historian and the philosopher as well as to the artist.

Within a few minutes walk from my dwelling place, I find myself in the middle of the Middle Ages and in the heart of Western Islām.

While I was winding my way through the narrow and tortuous streets of the old city, or contemplating wistfully the noble and melancholy landscapes which surround and crown it, I could not help thinking all the time of our common work and ideal and wondering how we could best accomplish the former and come nearer to the latter. What is the meaning of Science, of Knowledge, of Truth? What is the meaning of History? How can we reconcile Science and History? How can we humanize the scientific effort and widen the historical outlook in such a way that scientists may become better historians and better men, and that historians, reaching finally a deeper understanding of human progress, may become better men also? But I need not insist, for I have discussed these views so often that I can hardly reexplain them without repeating myself. All that I wish to say at present, is that I travelled far and wide in the Mediterranean world to obtain a deeper knowledge of the Middle Ages and Islām (and incidentally of the Arabic language), but that I obtained also in the bargain a richer and subtler grasp of my own effort in its relationship with other human efforts past and present. In the pathetic environment of this Muslim city especially, the old Fez, I dedicated myself anew with fresh enthusiasm to our great purpose—the New Humanism.

The historian must learn to contemplate scientific and even industrial progress without prejudice and without futile irritation. A blind admiration of the past is not simply sterile, but false, for the past was very much like the present in that it contained as much evil as good (2). It is perhaps better to insist chiefly on the best elements of life, but this applies to the present as well as to the past. On the other hand, the scientist must learn to appreciate more correctly and generously mediaeval and

(2) I really believe that the relative proportion of evil was greater in the past than in the present; that is, I believe in moral and social progress as well as in scientific progress. However, while the existence of the latter is obvious, that of the former must still be proved. I will try to prove it, as far as it can be done at all, in ulterior volumes of my *Introduction*.

XUM

oriental achievements. It stands to reason, but we forget it all the time, that we are the children of the Middle Ages far more directly than those of Greece and Rome. The Greek and Roman elements which loom so large in our culture have reached us only after having been transmitted to us and been modified in many ways by mediaeval minds—Jewish, Christian, and Muslim.

We must learn to look backward with gratitude and reverence, and yet to look forward with faith and charity: Never to break with the past, but only with the evil thereof; rather to continue its best traditions and to go forward and upward in the direction of its most generous and highest endeavours.

It is not—it can not be—our part to cure the political and economic ills of the world, but we can do something—however little—to strengthen the peace and good will, and to publish the goodness and beauty and wisdom of which there was —and is—so much, so very much, though we sometimes forget it. We can do that, and if we can we must.

***

To conclude, the Editor can do very little by himself, but much more with the help of his collaborators and his friends. He needs their help deeply and begs for it. If you share his faith, dear Reader, will you help him? If you do, he will be very thankful to you not in his name only, but in that of the whole *Isis* family. And in any case he will continue to do his best and be thankful also for that privilege, the greatest privilege of any man.

Fez, Morocco, July 18, 1932. GEORGE SARTON.

Ninth annual report of the corresponding secretary and treasurer of the History of Science Society for the year 1932

(For previous report, see Isis, 18, 5-6, 1932*)*

MEMBERSHIP

Total membership, January 1, 1932	594
Resigned, canceled, died during 1932	41
	553
Total new members for 1932	20
Total membership, December 31, 1932	573
Members paying to Brussels office	90
Members paying to Washington office	483
Total paid for 1932	431
Delinquent	52

EXPENDITURES

Isis	$ 1724.00
Printing and stationery	101.50
Secy.'s Assistant	200.50
Advertising	99.00
Stamps, tax, postcards	90.75
R.R. (Minn., Phila.)	105.00
A.C.L.S.	25.00
Rittenhouse bicentenary	30.25
Partial set *Isis*	30.50
Williams & Wilkins books	90.52
	$ 2497.52

CASH RECEIVED

From dues	$ 2155.00
Book fund	100.00
Sale of *Isis*	95.00
Sale of William & Wilkins books	90.52
Royalty (Newton vol.)	50.25
Gift	50.00
Total receipts	2540.77
Total expend.	2497.52
Balance	$ 43 25

CARNEGIE CORPORATION OF NEW YORK REVOLVING BOOK FUND

(Received May 15, 1929 ... $ 7500.00)

Savings account May 15, 1929	$ 7500.00
Interest to date	646.83
Total	$ 8146.83
• Paid out	2638.37
Total in savings account	$ 5508.46

• Paid to Columbia University Press	$ 500.00
Paid to Clarendon Press	1463.37
Office expenses	675.00
Total	$ 2638.37

F. E. BRASCH,
Treasurer.

Isis' Accounts for 1931 and 1932

The account for 1930 appeared in *Isis*, 15, 336-37, 1931. The Editor was not able to compile the account for 1931 because of a long absence in the Near East. The present account thus covers two years. During that period nine numbers have been published (45 to 53), including 60 memoirs, 144 shorter items and reviews, 3828 bibliographic notes, 5 facsimiles of scientific classics. A total of 2282 pages and 47 plates. The average cost of a plate equals that of 5.85 pages (1930). Hence for statistical purposes we may say that the members of the H. S. S. received in 1931-1932, 2557 pages. According to his contract with the H. S. S. (see *Isis*, 16, 125), the Editor is expected to publish 600 pp. each year. During the years 1931-1932, he published more than twice that amount.

The Editor's total loss for both years amounted to $ 1156.68. Part of it was repaid out of the remainder of the Swiss fund (see *Isis*, 15, 337), the net loss of the Editor being thus reduced to $ 795.34 or $ 397.67 per year.

SUMMARY OF ACCOUNTS FOR 1931 AND 1932

EXPENDITURES			RECEIPTS		
Printing	4417.64		H. S. S. 1931	1700	
Mailing	911.57	5329.21	1932	1724	3424.00
Royalties			Back vols.		73.88
in cash	20.25		Belgian dues & back vols.		1730.70
in reprints	303.19		Advertising (H.S.S.)		99.80
in gifts	55.32	378.76	Authors' contributions		87.00
Brussels office		527.57			$ 5415.38
Cambridge office		336.52			
		$ 6572.06			

XUM

Total expend.	6572.06
Total receipts	5415.38
Editor's gross loss	1156.68
Remainder Swiss fund	361.34
Editor's net loss	$ 795.34

COMPARISON BETWEEN 1930 AND 1931-32

(Figures in third column are yearly averages. Prices in dollars)

	1930	1931-32	*Diff.*
1. Nos. of *Isis*	4	4.5	+ .5
2. Pages	920	1141	+ 221
3. Plates & figs.	35 pl.	23.5 pl.	— 11.5
	23 fig.	7.5 fig.	— 15.5
4. Pl. plus p. (1 pl. = 5.85 p.)	1125	1278.5	+ 153.5
5. Printing and mailing	2617.42	2664.60	+ 47.18
6. Id. per p. (see 4)	2.33	2.08	— .25
7. Total publishing cost	3383.24	3286.03	— 97.21
8. Id. per p. (see 4)	3.01	2.57	— .44
9. Income from H.S.S.	1804.00	1712.00	— 92.00
10. Belgian income, back vols.	938.20	602.32	— 335.88
11. Total income	2744.58	2707.69	— 36.89
12. Gross loss	638.66	578.34	— 60.32

GEORGE SARTON.

Harvard Library, 185
December 13, 1932.

Section of the History of Science of the Carnegie Institution

Fourteenth annual report for the period extending from July 1, 1931 to June 30, 1932 (previous reports appeared in Year Books Nos. 18-30; the twelfth and thirteenth also in Isis, *15, 170-71 and 17, 209-17, respectively).*

Dr. GEORGE SARTON left Cambridge on July 26, 1931 for a much needed vacation and for a year's study in the East. The purpose of his journey was twofold : (1) to obtain a deeper and more fluent knowledge of Arabic, and to make a comparative study of the Arabic language as actually written and spoken in various countries; (2) to visit the countries of the Mediterranean world, especially the Muslim and Arabic ones, and those which had been submitted to Muslim influences in the past (as Greece, Sicily, and Spain).

These two purposes were somewhat conflicting, because the second one implied considerable traveling and—considering the length of the itineraries and the shortness of time—constant and frequent motion from one place to another; while the first could only be attained if Dr. SARTON stayed long enough in any one place. Moreover, for his Arabic studies, he needed a fair amount of books, far more than could be conveniently carried in his luggage.

It was necessary to compromise. A relatively long stay (1) was made in Beirut (Lebanon, Syria), where most of his time was devoted to the study of classical Arabic and of the Syrian dialect. This stay was made at once very profitable and very pleasant thanks to the hospitality and kind cooperation of the

(1) Deducting absences on short journeys in Egypt, Palestine, and Transjordania, 5 ½ months.

XUM

American University, whose generosity is deeply appreciated. He made a shorter stay in Tlemcen, an ancient Islamic capital, situated in the hills near the Moroccan border of Algeria. This enabled him to obtain a definite idea of Western Islām and of Algerian and Moroccan Arabic.

In order to accomplish his second purpose, as far as was possible in so short a time, he traveled extensively in Northern and Southern Syria, chiefly in the Lebanon, also in Palestine, and in Transjordania which he traversed almost completely from the capital, Amman (the ancient Philadelphia), down to Ma'an and Petra, along the pilgrim road to Mecca, and down to the boundary of Arabia.

He left Beirut in the beginning of May, and proceeded to the island of Rhodes and to Istanbul, then to Athens, to Rome, Naples, Palermo, and to Tunis. He crossed the whole of North Africa to Tlemcen, and is now on his way to Morocco. He plans to continue his study of Arabic in Fez, but the length of his stay in Morocco will depend on the weather which is rather inclement at this time of the year (July). However, he hopes to see a good part of Morocco, both of the French and Spanish regions, and then to visit the Muslim remains of Spain. After short stays in Paris, Brussels, and London, where he will meet a number of European orientalists and historians of science, he will finally return to America. He will be in his Cambridge office before the end of September.

It is difficult for him to draw final conclusions at this time, for he has gathered so many facts and impressions during his travels that it will take him years of " collateral " reading, study, and meditation to make full use of his accumulated experience. However, two important conclusions can already be formulated at the present time :

(1) The essential unity of the Arabic language—past and present—in all the countries visited by him. That unity is at least as great as that of any other language under similar conditions (particularly the lack of independence and political unity). That unity is largely accounted for by the religious (Muslim) unity of the vast majority of Arabic-speaking people.

(2) The essential unity of the Mediterranean world. The Mediterranean Sea favored communications far more than it

hindered them, and caused the existence of a unified culture along its shores, extending North and South, East and West. That unity was promoted by the imperialism of a number of peoples : Egyptians, Phoenicians (Carthaginians), Aegeans, Greeks, Romans, Byzantines, Muslims, Turks, and finally the various Latin and other European peoples having settlements and " interests " in that part of the world. This is of great importance, because the Mediterranean basin was really the cradle of European and American culture.

The work done by members of this Section during the year 1931-32 may be summarized as follows :

1. *Introduction to the History and Philosophy of Science.*—The second volume of Dr. SARTON's Introduction, From Rabbi ben Ezra to Roger Bacon (XXXV+1251 pages) was published for the Institution by The Williams and Wilkins Company of Baltimore, in November 1931. It consists of two parts, devoted to the Twelfth and Thirteenth Centuries, respectively. The General Index to the second volume—108 pages—was compiled, under the direction of Dr. SARTON, by Miss FRANCES SIEGEL (Radcliffe '31); after the departure of Dr. SARTON for Europe and the Near East, Dr. POGO completed the standardization of the cards, edited the typed manuscript, and read the proofs of the Index.

2. *Other investigations*—Dr. POGO has continued his study of the astronomical knowledge of the Egyptians of the ninth to eleventh dynasties. Most of his time was devoted to the editing of *Isis*.

Miss WELBORN pursued her investigations relative to science in the Fourteenth Century, especially to botany and medicine.

3. *Publication of Isis.* During the past year, with Dr. POGO acting as editor, five numbers of *Isis* have been published (47 to 51), forming the end of volume 15 (pages 504-630), volume 16 (586 pp.), and volume 17 (636 pages), a total of 1349 pages, 31 plates, and 13 figures. They contain 37 papers, 87 shorter communications and reviews, 1825 bibliographical notes, and Mr. L. GUINET's general index to volumes 13 to 15.

4. *Lectures.*—Dr. SARTON delivered four lectures to the American University of Beirut, one to the Muslim College of the same city, and two to the Hebrew University of Jerusalem. These lectures were largely devoted to the explanation of Arabic science,

and of the mediaeval sources of our knowledge and our culture. These sources were partly Jewish, partly Christian, partly Muslim. The Jews alone would have failed, the Christians alone would have failed, the Muslims alone would have failed. Together they succeeded and each of us owes gratitude to all of them.

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— See SARTON, GEORGE.

WELBORN, MARY CATHERINE. Lotharingia as a center of Arabic and scientific influence in the XIth century. *Isis*, vol. 16, 188-199 (1931).

— The errors of the doctors according to Friar ROGER BACON of the Minor Order. *Isis*, vol. 18, 26-62 (1932).

The Text of Grosseteste's De Cometis

The manuscript tradition available to Dr. LUDWIG BAUR (1) for the edition of this work was hardly a satisfactory one. He had three Mss, all from the second half of the fourteenth century, offering, apparently, two recensions. That at least seemed the reasonable solution of the problem presented by the fact that one Ms (Berlin Ms lat. 963, ff. 129^{rb}-130^{ra}) had a considerable section of the tractate *De Cometis* in common with the other two Mss (Erfurt Amplon. Q. 361, f. 126^{r-v} and Clm 588, ff. 113^{va}-114^{rb}). The latter " recension " was an undisguised paraphrase of a short section of PTOLEMY's Almagest, describing nine *stellae cum caudis*, Veru, Conaculum, Pertica, Miles, Dominus Aschone, Maculia or Aurea, Argentum, Rosa and Virga, to which had been added a section by GROSSETESTE in which he sums up the causes and nature of comets. But this " recension," taken as a work by itself, lacks GROSSETESTE's customary clearness and careful workmanship. BAUR rightly recognized this weakness by relegating it to a footnote.

The first " recension " (in the Berlin Ms) was more successful, in that it treated fairly thoroughly, albeit succinctly, the source and nature of comets. But what it had gained in completeness it had lost in arrangement. It begins (BAUR, *op. cit.*, p. 36) : *Relictis opinionibus de natura tricarum, quas possibile est, ut formet sibi animus ab experimentis in rebus naturalibus, cum non profundaverit in eis ratiocinationes scientiarum spiritualium...* (BAUR here remarks : *sine dubio lacuna*) *Cum autem in regione...* etc. One is immediately struck by the fact that the work begins by a reference to something with which the reader is expected to be familiar.

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(1) LUDWIG BAUR, *Die Philosophischen Werke des Robert Grosseteste, Bischofs von Lincoln*, in *Beiträge zur Geschichte der Philosophie des Mittelalters*, Bd. IX (Münster i. W., 1912), in Introduction, 69*-72*, text, 36-41.

XUM

Appended to this text in the Berlin Ms is a short section: *Opiniones circa cometam*, beginning: *Dico tamen quod hi qui considerant et experiuntur in rebus... de natura tricarum...*, and giving four current *opiniones*. It would appear that the tract in course of transmission had been turned end for end. Were there these four *opiniones* at the beginning of the work, we could better understand the *Relictis opinionibus de natura tricarum...* But we would have no right to reconstruct the tract without definite Ms authority. Fortunately we have such authority in a Ms not known to BAUR in the Biblioteca Marucelliana in Florence, Cod. C. 163. Dr A. G. LITTLE, in his " List of Roger Bacon's Works " in *Roger Bacon, Essays*, (Oxford, 1914,) p. 379, item 12, lists this tractate, found among works of BACON in Florence, Bibliotheca Riccardiana, Ms. 885, ff. 113-114. It is not here specifically ascribed to BACON, however. It is more likely to have been used by BACON in his *De Multiplicacione Specierum*, pt. I, cap. ii. The absence of a Ms. attribution to BACON warrants us in recognizing the ascription in the three Mss. of the various recensions in which the work appears as determinative. This is a paper codex, large quarto size, written in two columns by an Italian scribe in the latter half of the fourteenth century. Its value is, furthermore, greatly enhanced by the fact that it contains more of the *philosophico-naturalia* of GROSSETESTE than any Ms used by BAUR. Of the 28 genuine works of GROSSETESTE edited by BAUR, this Florence Ms contains 23 (2), in addition to an *opus ineditum*, *De Accessu et Recessu Maris*, i.e. all but the *De Impressionibus Aeris*, *De Anima*, *De Sphaera*, *De Luce*, *De Potentia et Actu*. This is the most extensive attempt to build a corpus of GROSSETESTE's *opera physica* thus far known. Although the text in itself is not above reproach, the whole represents an excellent tradition. This fact is strikingly illustrated by the form in which the *De Cometis* is presented. There are two tractates instead of one. The first contains the substance of the Berlin Ms, with a few additional sections;

(2) The S. Marco, Venice, Ms VI. 163, BAUR's most extensive codex, contains 18 of the 28 works. A fourteenth century paper codex in the National Museum in Prague, XII. E. 5, contains 19 of the 28 and the *De Accessu et Recessu Maris* (a tract recently noticed by F. Pelster in an Assisi Ms. Cf. *Scholastik* I (1926), 572 f.), which I am publishing elsewhere.

the second is essentially that of BAUR's second "recension," which, if regarded as an appendix to the main tractate, presents no difficulties, because making no great claims to completeness or unity.

The arrangement of the substance of the first "recension," however, is the important feature of the Florence text. There is first the occasion for the treatment of the subject at all, lacking in the Berlin copy, then the *Opiniones circa cometam*, with a few unique sections, noted in the appended transcription, then GROSSETESTE's own argument. It is thus a neatly arranged treatise, exhibiting the compactness and order of the vigorous period of Scholastic thinking, and, though short, a credit to ROGER BACON's predecessor.

In the subjoined text brackets around a section indicate that it is present in the Florence text, but absent entirely from the Berlin copy. The numbers of the paragraphs are arbitrarily added to make convenient an explanation of the order in which the matter appears in the Berlin Ms. An attempt to date the composition of the tract will follow the text. The spelling of the text is retained throughout. Variants from the Berlin Ms, though numerous, are not noted; it may be pointed out, however, that the text is superior to the printed tradition.

Florence, Biblioteca Marucelliana, Cod. C. 163.

LYNCONIENSIS DE COMETIS ET CAUSIS IPSARUM

(1) [Occasione comete que nuper apparuit animum applicui ad cogitandum aliquid de natura cometarum. (f. 20ᵇ) Mihi indagenti innotuerit deus (3) ad utilitatem communem in lucem proferre curavi.]

(2) Dico ergo in principio quod hii qui considerant et experiuntur in rebus et formant sibi opinionem ex experimentis suis absque profundidate racionum necessario incidunt in oppiniones falsas, sed de natura cometarum eciam est diversitas secundum diversitates experimentorum suorum quibus usi sunt in radia-

(3) This is the reading of the codex. The Florence Ms (s. XIII) has a better reading:... cometarum, et quod mihi indaganti de eis innotuit ad communem... etc.

tionibus et generationibus ignium, in apparitionibus in visu per medium diafanorum. Qui autem experti sunt quod radii solis incidentes in speculum reflectantur multoties cum radiatione visibili et sciunt cum hoc quod stelle sunt specula reverberantia radios super se incidentes, prope sunt ut opinentur caudam quam trahit esse radiositatem solis a stella reflexam.

(3) [Sed hec opinio refellitur duobus modis. Primo quia non est radiositas reflexa visibiliter nisi cum radii reflexi admiscentur dyafono naturali terrestri, non celesti.]

(4) Secundo quia non semper protenditur cauda comete in oppositum solis cum radii omnes reflexi eant in oppositum, incidunt autem ad angulos equales.

(5) Qui eciam sunt experti quod ex concursu radiorum multorum attenditur ignis et inflammatur res inflammabilis prope sunt ut opinentur radios multos concurrere in summo aere quo elevantur fumi accensibiles, ibique per concursum radiorum fumum inflammari ipsamque inflammationem apparere stellam caudatam. Ista iterum opinio falsificatur, quia si esset concursus radiorum a stellis recte descendentium, cum non possit esse a stellis fixis, tantum, quia concursus ille semper esset stabilis et manens accendens radiorum recte descendentium a planetis tantum, et cum planete permutent velociter suum situm, non posset ille concursus diu accendere. Comete autem vise sunt per sex (4) menses durasse.

(6) Si autem concursus radiorum ascendentium per reflexionem factam sicut a speculo concavo vel per congregationem sicut per transitus per medium perspicuorum spericorum, tunc occasio ibi concursus radiorum esset corpus naturale sublunare, si vapor concavus aut spericus cuius figure mansio non potest esse diuturna nec sequitur eius motus motum celi necessario. Duratio autem comete quandoque diuturna est, ut diximus, et motus eius sequitur motum celi diurnum.

(7) Qui autem considerant quod res multe propinque a distantia a se apparent continue sciuntque cum hoc quod gallaxio est congregatio stellarum propinquarum in iudicio visus concursarum, prope sunt ut ex hac similitudine formant sibi opinionem quod cometa sit aggregatio plurium stellarum propinquarum secundum

(4) *The Berlin Ms has* octo menses.

figuram in qua apparet cometa orta in hora apparitionis illius concurrentium.

(8) Et hec opinio destruitur quia non semper apparent comete in via stellarum erraticarum sed extra eam pluries. Qui autem experti sunt quod propter figuram (f. 21ª) perspicui interpositi inter videntem et rem visam possibile est ut res una appareat alterius figure qualiscunque secundum exigentiam figure perspicui interpositi prope (5) sunt ut opinentur cometam stellam esse apparentem.

(9) [In magnitudine et figura non solita propter vaporem perspicuum interpositum figuratum proportionaliter magnum et figure comete vise. Ex hac enim apparent multocies soles plures et lune plures. Hanc vero destruit id quod dictum est, scilicet quod vapor elevatus non retinet diu figuram unam nec sequitur necessario motum celi.]

(10) Hec ergo sunt opiniones de natura talium apparitionum quas possibile est ut preformet sibi animus experimentis in rebus naturalibus cum non profundaverunt cum eis rationes scientiarum specialium. Cum in regione superlunari nichil renovatur preter situm et ea que ex situ renovato accidunt ut eclipsis et radiorum proiectiones visibiles et crementum et decrementum lune, manifestum est quod cometa non est stella nova nec aliquod novum in regione superlunari. Quid igitur in visione comete est res existens sub globo lunari? Palam autem ex luce et splendore comete quem trahit cometa quod cometa illa nichil aliud est quam ignis, quia sub luna et supra nos nichil lucet et splendet nisi solus ignis. Ignis autem duplex est quia aut est manens non simul cum generatur desinens qualis est ignis elementum in sua spera; alius est ebulitio fumi accensi simul cum generatione sua desinens qualis est flamma apud nos genita. Non est autem possibile ut materia comete sui sit ignis simul cum generatione sua transiens, quia non haberet materiam continue foventem eam in diuturnitate sue permanentie, nec sequitur materia illum motum celi diuturnum cum esset natura terrestris non complete sublimata. Non enim videmus aliquos ignes ex materia terrestri in aere generatos diuturne permanentie nec motum celi sequentes. Relinquitur ergo quod cometa (6) ignis manens non cum generatione sua transiens. Hunc autem descendere in regionem aeris

(5) *Cod.* proprie.
(6) *Supple* sit.

spera ignis elementi non est possibile, quia non descendit ignis elementum cum corpulentia a spera sua sed virtus eius tantum descendet cum radiis stellarum in spera eius ignitis, nec attingit ad speram ignis generatus ex materia desursum veniente sed a materia deorsum veniente, quia non est possibile ut generetur ignis habens diuturnitatem permanentie nisi cum fuerit materia sublimata separata a materia terrestri et assimilata nature celesti. Palam igitur est quod cometa est ignis sublimatus separatus a natura terrestri et assimilatus nature celesti. Cum agens et paciens completa actione assimilentur cum prius fuerint (f. 21^{b}) dissimilia causa naturalis comete necessario est virtus celestis, scilicet virtus stelle fixe vel errative, et verisimile est quod unicuique comete est causa effectiva propria stella e directo cum movetur cum qua apparet in iudicio nostri sensus. Cum autem comete moveantur motu celi diurno, patet quod virtus celi primi est causa motica in ipsis, et obedientia ista quam habent comete ad mutationem celi primi signum est sublimationis eorum, id est separationis a natura terrestri et assimilationis nature celesti. Locatio autem comete e directo unius stelle plusquam e directo alterius non est nisi per assimilationem maiorem illi stelle e directo cuius locatur que propter similitudinem quam habent cum stella illa cuius virtus eam sublimavit; trahetur a stella illa sicut ferrum ab adamante. Cum autem stella que sublimavit comam sit de natura unius septem planetarum eo quod omnis stella est de natura unius eorum, palam eciam est quoniam eciam coma est ignis sublimatus assimilatus nature unius septem planetarum. In omni enim re complexionata terre sunt res corporales spiritales assimilate naturis celestibus incorporate ipsis rebus complexionatis que res spiritales separabiles sunt a rebus complexionate per actionem corporum celestium. Cum sit hec separatio relinquitur res complexionata a natura celesti et infirmatur aut corrumpitur. Partes autem mundi huius sensibiles sunt facilioris et velocioris resolutionis quam sint partes rerum complexionatarum, licet totus mundus sensibilis sit incorruptibilis et quelibet res complexionata tota sit corruptibilis.

(11) Ex hiis ergo apparet quod cometa que est ignis sublimatus a parte mundi sensibilis signum est precedentis sublimationis et separationis nature spiritualis incorrupte rebus complexionatis et assimilatis terre in natura spirituali quapropter signum est

infirmationis aut corruptionis rerum complexionatarum quibus dominatur planeta vel stella alia de natura planete.

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A comparison of our text with that of the Berlin codex, as printed by BAUR, shows that the latter has but seven of the eleven sections and in the following order :

Section (10) p. 36, l. 14 — p. 39, l. 5
(11) p. 39, ll. 5 — 11
(2) p. 40, ll. 18 — 28
(4) p. 40, ll. 29 — 31
(5) p. 40, l. 32 — p. 41, l. 12
(7) p. 41, ll. 13 — 19
(8) p. 41, ll. 20 — 26

Sections 1, 3, 6 and 9 of the Florence Ms are wanting in the Berlin copy, yet they are all necessary to the even development of the argument. But between sections 11 and 2 the Berlin codex has the section which it has in common with the second " recension," which, though belonging in the paraphrase of PTOLEMY, is but a *résumé* of the argument already elaborated in section 10, and consequently quite out of place in this tractate.

The mention, at the beginning of the tractate, of a comet *que nuper apparuit* may be of some use in dating the composition of the work. It may be of interest to suggest that, with an orbit of ± 75.9 years, HALLEY's comet, first definitely observed in 1456, was due some time during the year 1228, that is, its third appearance previous to 1456. There has hitherto been no reference to its appearance in this year which is more verifiable than this conjectural one by GROSSETESTE. If that is so, we have GROSSETESTE, early in the period of his teaching activity at Oxford, from 1229, using HALLEY's comet as an occasion for a general treatment of the subject of the cause and nature of comets. It may be added that internal evidence, of a somewhat doubtful nature, be it said, such as a certain lack of finish and definiteness in expression, would tend to class this short tract as an early composition. Reliance on such evidence must be controlled by the pertinent fact that the Ms ascription is not of the thirteenth century, but certainly the second half of the fourteenth.

Oxford S. HARRISON THOMSON.

XUM

Astrology in Shakespeare's day

Part One

THE ATTITUDE OF THE OPPONENTS

During the days of Shakespeare, as in other times, there were many authors who did not accept the tenets of astrology. For the most part, however, these writers were in some way connected with the church. Such a condition was to be expected, because the chief arguments against this science were theological. Indeed, had there been other potent reasons against its acceptance, astrology would have been less popular. The fact is that practically every one opposing astrology did so not because he felt its practitioners were unable to foretell events, but because he believed astrologers had recourse to the aid of devils. Almost the only other valid consideration against astrology was its abuse, and it is a significant fact that the astrologers themselves admitted this and tried to correct it.

The controversy over the validity of astral prognostication concentrated on judicial astrology, because a majority of the upper classes abhorred the use of almanacs, and accepted the belief in the efficacy of comets and eclipses in foretelling dire events. (1) Nor was a credence in the effect of the stars upon seeds, trees, the weather, or human bodies endangered by the attack upon judicial astrology. William Rowland, for example, wishes it clearly understood that neither he nor his friend Dr. Homes, intends to dispense with all astrology but merely with the judicial branch. They both believe that there are signs in the heavens indicating such things as the alteration of weather, the proper

(1) Cf. my paper "Elizabethan Almanacs and Prognostications," *The Library*, New Series, XII (1931), pp. 83-108, 194-207.

time to plant, and the proper time in which to let blood or to purge. (2)

One of the early writers against astrology in this period, was FRANCIS COXE, a quack doctor. He was summoned before the Privy Council on a charge of sorcery, severely punished, and made a public confession of his ' employment of certayne sinistral and divelysh artes.' This confession took place at the Pillory in Cheapside on June 25, 1561. Shortly after, in the same year, he published his recantation, *A Short Treatise declaringe the Detestable Wickednesse of Magicall Sciences*, which one modern writer calls a ' grovelling and terror-stricken pamphlet.' (3) The case of HENRY HOWARD, the author of the *Defensatiue against the Poyson of Supposed Prophecies*, I have considered elsewhere. (1) It will be sufficient here to indicate that he had always been engaged in court intrigue, and upon publication of this work he was arrested and imprisoned on a charge of treason and heresy. Two other anti-astrological writers, JOHN GAULE and JOHN MARBECK, were divines. Another author who attacked prognostication by the stars was JOHN CHAMBER, Canon of Windsor. His *Treatise against Iudicial Astrologie* was published in 1601 along with a lecture in praise of legitimate astronomy, which he had delivered some years earlier. This work is perhaps the best known repository of the general opinions of those opposing astrology; it was attacked at length by CHRISTOPHER HEYDON in 1603. A friend of CHAMBER's defended him against HEYDON, and in 1624 appeared *The Madnesse of Astrologers* written by GEORGE CARLETON, Bishop of Chichester. Two other ministers who offered considerations against the validity of astrological predictions were the well-known STEPHEN GOSSON, and the anti-Catholic WILLIAM PERKINS. In the familiar *Discoverie of Witchcraft*, too, REGINALD SCOT includes an expression of his opinions concerning the subject. Finally, there was JOHN MELTON, a politician and M.P., who printed his *Astrologaster* in 1620. MELTON, however, takes a view toward astral prognostications which is more liberal than that of the others. He not only agrees that astrologers may foretell truly if they have supernatural aid, but adds,

(2) WILLIAM ROWLAND, *Judiciall Astrology Judicially Condemned*, London, 1652, pp. 4-5.

(3) Cf. *Dictionary of National Biography*.

Yet I cannot deny altogether, but that future Contingences may bee seene by the Contemplation of Heauen. For there is none can doubt, but that God, the great Architect of this visible and inuisible World, infused a manyfold vertue and operation in the Heauens : but that many of these Qualities are secret, and occult, the Kingly Prophet *Dauid* telleth vs, saying; God numbreth the multitude of Starres, and imposeth seuerall Names vnto them. Therefore it is manifest, that things are named according to their properties, which none but hee that made them, can perfectly and distinctly vnderstand. (4)

This concludes the list of the opponents of astrology which I have examined, except for three men whose names do not appear in the *Dictionary of National Biography* (WILLIAM ROWLAND, JAMES CLELAND, and DAVID PERSON), and HENRY CORNELIUS AGRIPPA who, of course, was not an Englishman although his work was translated into English.

The arguments of these men will now be examined, beginning first with the general considerations. During the Elizabethan period, there were no new grounds advanced for an opposition to the science of astrology, all of the objections being stock ones derived from the Middle Ages and earlier. The discussion of twins offers an excellent illustration in point, originating as it does in ST. AUGUSTINE'S *De Civitate Dei* and his *De Doctrina Christiana*. WILLIAM PERKINS refers to Jacob and Esau as being born so close together that one held the other by the foot. How, he asks, can the astrologers consider this a separate birth? And if they do, it must be well nigh impossible to ascertain the exact time of birth so that twins may have separate horoscopes. (5) This argument offers such strong proof against astral predictions, believes HENRY HOWARD, that astrologers are sorely tried to answer it. (6) The most extended account of the problem is found in JOHN CHAMBER, who discusses it in a separate chapter of fifteen pages with two illustrations. This author states that if the stars move so swiftly that twins require different figures of the heaven, then they must move too fast for the astronomers to observe them. He gives an account of two pairs of Siamese twins (one set of males and one set of females) in neither case of which did the individuals die at the same time, nor even of

(4) JOHN MELTON, *The Astrologaster*, London, 1620, pp. 33-34.
(5) WILLIAM PERKINS, *Works*, London, 1605, p. 127.
(6) HENRY HOWARD, *A Defensatiue against the poyson of supposed Prophecies*, London, 1583 (reprinted, 1620), fol. 56.

the same disease. We must consider, too, says CHAMBER, the case of the Countess of Holland, who had three hundred and sixty-five children, 'al hatched at once'; is it possible, he asks, that all of these had the same fortune? The question is further complicated, believes CHAMBER, by the problem of conception; even if it be granted that twins are born at separate times, the astrologers must admit that they were conceived at the same moment, and is this not more important than the time of birth? (7)

In conjunction with this discussion of twins, there is another argument growing out of deaths by catastrophe. Shall we say, ask STUBBES and others, that all those living in Sodom and Gomorrah were born under the same planet? Or did all those living at the time of the universal deluge of Noah have the same horoscope? Obviously not, they say; and yet many disasters of this sort must be taken into account, as for instance, shipwrecks, battles, fires, sacks of cities, etc. (8)

The question of twins, as we have noted, led the anti-astrologers to say that if the time between twins required separate horoscopes, it must be almost impossible to set down the exact time of birth. In recording it, besides, many difficulties must arise, say these men. Bashful man must be admitted to the birth chamber; his view must be unobstructed; the birth must be by day (so that the sun may be observed); there must be no clouds; and finally the instrument of solar observation must be perfect and exact 'as perhaps it neuer is.' (9) SAMUEL BUTLER makes use of this consideration as Hudibras tries to point out to Sidrophel (WILLIAM LILLY?) the absurdities of astrology :

> There's but (the) twinkling of a star
> Between an Man of *Peace* and *War*,
> A *Theif* and *Justice*, *Fool* and *Knave*,
> A huffing *Offi(c)er* and a *Slave*,
> A crafty *Lawyer* and a *Pick-pocket*,

(7) JOHN CHAMBER, *Treatise against Iudicial Astrologie*, London, 1601, pp. 49-63. This consideration of twins is taken from ST. AUGUSTINE's *De Civitate Dei* (book V), from his *De Doctrina Christiana* (book II), and from ST. GREGORY's *Homil.* X sup. Evang. (see CHAMBER, p. 50). For other references, see WILLIAM ROWLAND, *op. cit.*, p. 185; and MELTON, *op. cit.*, p. 39.

(8) PHILIP STUBBES, *The Anatomie of Abuses*, London, 1583 (reprinted by New Shakespeare Society, series 6, vols. 4 and 12), part II, p. 62 (cf. 55-66); and CHAMBER *op. cit.*, pp. 27 and 133 (*sic*, really 131).

(9) HOWARD, *op. cit.*, fol. 67. Cf. CHAMBER, *op. cit.*, pp. 19-20, 24, 28-29.

A great *Philosopher* and a *Blockhead*,
A formal *Preacher* and a *Player*,
A learn'd *Physitian* and the *Man-slayer*.
As if men from the Stars did suck
Old-age, *Diseases*, and *ill-luck*,
Wit, *Folly*, *Honor*, *Virtue*, *Vice*,
Trade, *Travel*, *Women*, *Claps*, and *Dice*.
And draw with the first Air they breath,
Battel, and Murther, sudden Death. (10)

Following early writers, such as PLOTINUS, the authors of Elizabethan anti-astrological tracts consider the problem of stars as causes. Do the stars enforce their effects (*i.e.*, are they causes of good or bad), or do they merely incline the soul? These writers are unanimous in believing that the stars serve only as indicators. Says STUBBES,

Indeede, I confesse they haue effects and operations, but yet are they not the efficient causes of any thing either good or bad. Otherwise than thus, it pleaseth the maiestie of God to worke by them, as by his instruments, whatsoeuer is his good wyll and pleasure, and not after any other sort, (11)

In other words, if the stars are causes then man is forced to do either bad or good according to them and has no recourse to free will; he is therefore not responsible for his actions. DAVID PERSON agrees with this statement and adds that he, too, believes stars can incline men's wills. According to WILLIAM PERKINS,

the starres haue a very great force, yet such as manifesteth it selfe onely in that operatiõ which it hath in the foure principall qualities of naturall things, namely in heate, colde, moysture, and drinesse : ... (12)

In making these concessions to astrologers, however, such writers played into their opponents' hands. Astrologers, too, admitted that if the stars enforced their effects, free will would be nullified. GEORGE CARLETON sums up the astrologers' attitude, accepting the concessions of Perkins :

The Starres incline the humour, the humour inclineth the body, the body inclineth the minde; through all these inclinations the starres come at last to worke upon the Soule. (13)

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(10) SAMUEL BUTLER, *Hudibras*, London, 1905, part II, p. 176; cf. pp. 152-158. Cf. JOSEPH F. CURTISS, " Butler's *Sidrophel*," *P.M.L.A.*, XLIV (1929), pp. 1066-1078.

(11) STUBBES, *op. cit.*, part II, p. 62.

(12) PERKINS, *op. cit.*, p. 40; cf. DAVID PERSON, *Varieties*, London, 1635, p. 186.

(13) CARLETON, *The Madnesse of Astrologers*, London, 1651 (first edition in 1624), p. 18; cf. pp. 5, 20-21, 42-49.

Being an opponent of the astral science, however, CARLETON adds that this influence is too vague and too difficult to be ascertained for practical purposes.

Astrologers are especially taken to task for avoiding the consideration of certain facts. They blithely tell us, says AGRIPPA, that

> the effectes, the forces, and mouinges of all liuinge creatures, stoones, mettals, hearbes, and what thinges so euer be created in these inferiour places, doo proceede from the Heauens,... (14)

but they forget that God created herbs, plants, and trees before He made the heavens and the stars. We learn further from astronomers, writes CHAMBER, that there are some 71,209,600 stars in the heavens, while astrologers list only 1028 as being known; they must therefore confess that they proceed with the help of too small a part of the astral bodies. Not only are certain visible stars not taken into account, continues CHAMBER, but the astrologers do not consider the great number of invisible bodies; have these no effect? It would be bad enough, he concludes, if the astrologers made use of the 1028 listed stars, but they do not; their system employs merely the seven planets; how, then, can we have any faith in their predictions? (15) Of even more importance is the subject of traditions which, according to CHAMBER, the astrologers have neglected. They say, he tells us, that their science is based upon actual observation; but how is this possible? Does it not take at least 36,000 years to make a second observation of any one nativity? If we take an example from physic, argues CHAMBER, a doctor may learn that a wound in the head is often fatal because many have died of such a wound; in astrology, however, it is practically impossible to discern the actual effects of any particular figure of the heavens (16). Astrologers answer, continues this author, that the Chaldeans kept a record of nativities for 407,000 years. This is clearly impossible, he contends, because it is not yet 6,000 years from

(14) HENRY CORNELIUS AGRIPPA, *Of the Vanitie & Vncertaintie of Artes and Sciences*, London, 1569, pp. 44-45.

(15) CHAMBER, *op. cit.*, pp. 16, 123-125.

(16) CHAMBER, *op. cit.*, p. 60; PERKINS, *op. cit.*, p. 40; ROWLAND, *op. cit.*, pp. 8-9; and MELTON, *op. cit.*, p. 29.

XUM

the beginning of the world, and not yet 4,000 years from the division of tongues (17).

There cannot be a greater argument, declares MELTON,

> of the falsenesse of Astrologers, then the deadly Antypathie that is betweene them concerning the Art it selfe : for some of them hold, that the Degrees, Planets, Qualities, Apparances, Ends, Exaltations, and Fallings, they attribute to the Planets, may be attayned vnto by diligent obseruation of the Effects of the Heauens, who by degrees may come to the knowledge of the Causes : ...

Such a deadly enmity exists, he assures us,

> betweene these Heauenly Doctors, that like so many Masters of the Noble Science of Defence, they striue to breake the head of each others reputation, and stand at defiance with each other. (18)

HENRY CORNELIUS AGRIPPA had previously made a similar statement :

> I dare saye with Plinie, that the inconstauncie of this Arte dothe openly declare, that it is no Arte, for so muche as touching the principles thereof the Indians haue one opinion, the Chaldeans an other, the Egyptians an other, the Moores an other, the Iewes an other, the Greeks an other, the Latins an other, the auncientes an other, & the latter Writers an other. (19)

According to CHAMBER, the astrologers are at odds with each other even with regard to the location of the planets. The Egyptians, he says, agree with PLATO and ARISTOTLE, placing the Moon immediately beneath the Sun; PTOLEMY, the Chaldeans, and later writers, on the other hand, understand the Moon to be the lowest of the planets (20).

Similarly, AGRIPPA informs us that there are many astrologers (including PTOLEMY) who feel that it is impossible to ascertain anything concerning the knowledge of judgments or of particular nativities. If this be true, he maintains, astrological prophecy

> dothe not so muche consist in Arte, as in a certaine diffuse chaunce of thinges : and as by chaunce, not by Arte, the Verse dothe rise vp out of the Bookes of pastime, neuer tellinge the truthe, so also out of the Astrologers minde doo prophecies proceede not by Arte, but by chaunce, ... Wherefore this Arte is nothing els but a false coniecture of superstitious parsons, which thorow long practise haue made a Science of things vncertaine, whereby they deceiue the simple sorte,

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(17) CHAMBER, *op. cit.*, p. 61.

(18) MELTON, *op. cit.*, pp. 29-30.

(19) AGRIPPA, *op. cit.*, p. 41.

(20) CHAMBER, *op. cit.*, p. 90; for similar discussions cf. HOWARD, *op. cit.*, fol. 65, and ROWLAND, *op. cit.*, p. 179.

to thende to spoile them of theire monie, and they themselues are deceaued also. (21)

The very terms (and their connotations) used in this science, believes ROWLAND, are subjects for laughter. We do not expect, he declares, that a man should change his quality in every inn, or that he who deals in Cheapside must become a mercer while in a mercer's shop, a goldsmith in a goldsmith's shop, etc.; then why should we think that planets are affected by the houses in which they are posited? Again, he asks, why do astrologers say the Sun is most hot and fervent in Cancer, a sign which is neither its house, nor its exaltation, and which is not a fiery sign but a watery one? It is not likely, ROWLAND protests further, that God

would garnish and adorne his seate of Maiesty with Images of Lyons, Tygres, Beares, and sometime of monsters also, as *Centaurus* and such like, warring and contending (without end) among themselues. (22)

Sir THOMAS MORE assures us that although the philosophers in Utopia were cunning in understanding the course of the stars,

yet as for the amityes and dissentyons of the planettes, and all that deceytefull diuynatyon by the starres, they neuer asmuch as dreamed therof. (23)

Believing that the proof of the pudding is in the eating, the opponents of astrology propose to examine some particular prognostications and compare them with the sequent events. Their chief basis for attack, of course, is the yearly prognostications of the weather. No matter how inevitable, from its causation, the resulting weather may be, insist these authors, the prognostications of it in the almanacs are but conjectures, and daily prove false (24). These objections to prognostications in almanacs are not the only ones, for most of these writers have found examples of false predictions in history. HOWARD, for example, seems to derive from AGRIPPA the cases of POMPEY, CRASSUS, and CAESAR, none of whom, the astrologers predicted, would die unless he were old, in his own house, and greatly honored; yet each of these died a violent death, before his natural time (25).

(21) AGRIPPA, *op. cit.*, p. 45; cf. CHAMBER, *op. cit.*, p. 16.
(22) ROWLAND, *op. cit.*, fol. 61; cf. fols. 57-58.
(23) Sir THOMAS MORE, *Utopia*, Oxford, 1905, pp. 186-187.
(24) ROWLAND, *op. cit.*, p. 74; HOWARD, *op. cit.*, fol. 111.
(25) HOWARD, *op. cit.*, fol. 112; AGRIPPA, *op. cit.*, p. 47.

XUM

The astrologer BALLANTIUS is said to have warned SAVONAROLA against fire; yet the former was neither able to foretell nor prevent his own great peril, for he was cruelly murdered, while SAVONAROLA was burned to death (26). Nor is it necessary, believes HOWARD, to go to history for examples :

> It is an ordinary case to finde martiall men borne vnder *Venus;* venerous wantons vnder *Mercury;* melancholy students vnder *Iupiter;* Iesters vnder *Saturne;* and constant friends vnder the Moone, which giueth a proud checke to the base coniectures of Astrologye. (27)

Not only were the prognostications often false, urged the opponents of astrology, but they did much harm as well. As I have pointed out elsewhere (28), the yearly prognostications were used to advantage for political purposes. FRANCIS COXE says that the predictions of NOSTRADAMUS were especially to be lamented :

> For although it was well knowē vnto all mē, what loue and godly zeale, her most royal maiestie had and did bear to the trew prophetes of God, his afflicted flock & woorde of the crosse, yet did the people so wauer, the whole realm was so troubled & so moued with the blinde enigmatical and deuelish prophestes [*sic*] of that heauen gaser Nostradamus, in such sort, that euen those whiche in their heartes coulde haue wished the glory of God and his worde moste florishing to be established: were broughte into suche an extreme coldenes of faythe, y^{t} they doubted God hadde forgotten hys promise,... (29)

According to WILLIAM ROWLAND, the astrologers further do mischief by dissuading men of quality from marrying worthy gentlewomen. They do this, he says, by casting false horary horoscopes which indicate that certain women are not virgins. The findings of astrologers in such cases, states this author, are merely lies which disable the reputations of the gentlewomen (30).

Except for arguments based on the fact that astrology lent itself so readily to trickery, the weightiest considerations offered against prognostication by the stars were, as has been said,

(26) HOWARD, *op. cit.*, fol. 126.

(27) HOWARD, *op. cit.*, fol. 56; MELTON, *op. cit.*, pp. 39-41.

(28) *The Libraty*, New Series, XII (1931), pp. 88-91.

(29) FRANCIS COXE, *A Short treatise declaringe the detestable wickednesse of magicall sciences, as Necromancie, Coniurations of spirites, Curiouse Astrologie and suche lyke*, London, 1561, A4v-A5r.

(30) WILLIAM ROWLAND, *op. cit.*, p. 7.

theological. The opponents maintained, first, that the practice of this science was prohibited by God through the words of the Bible. JAMES CLELAND indicates this feeling in discussing the various subjects which must be studied by the young gentleman :

> As for *Astrologie*... I would haue it hid from a young Noble mans eies, as forbidden by Gods own Mouth : ... (31)

There are several Biblical quotations which delight the opponents of astral divination. *Isaiah* 47 : 13 is a favorite :

> Let now the Astrologers, the Star-gazers, the Monethly-Prognosticatours stand up and save thee from those things that shall come upon thee. Behold, they shall be as stubble, the fire shall not burn them; they shall not deliver themselves. (32)

Isaiah and *Jeremiah* are the most quoted books. If certain passages give pleasure to the opponents of astrology, however, there are an equal (if not larger) number which cause them difficulty. What is meant, for example, when the stars in their courses fought against SISERA ? JOHN GAULE suggests that 'stars' may have been metaphorically understood as angels (33). Again, when MOSES said that the stars were put in their places to serve as signs, was not this a sanction of astrology ? CARLETON believes that these signs ' pertaine to naturall and politicall Orders and Seasons ' (34).

Foreknowledge, maintain the anti-astrological authors, is a power which God reserved for Himself. Says PHILIP STUBBES,

> Those things that are aboue our reach, conserne vs not, therefore we ought not to enter into the bowels & secrets of the Lord... For to them that goe about, and labour so buselye by speculations, by astronomie, astrologie, and the like curious arts to iudge of things to come, and thinke they can tell all things by the same,... Christ our sauiour saith, ... It is not for you to knowe the times and seasons, which the Lord God hath reserued to himselfe. (35)

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(31) JAMES CLELAND, *The Institution of a Young Noble Man*, Oxford, 1607, pp. 92-93.

(32) ROWLAND, *op. cit.*, title page; JOHN MARBECK, *A Booke of Notes and Common Places*, London, 1581, p. 78, cf. pp. 79-80. Also cf. CHAMBER, *op. cit.*, pp. 4-5.

(33) JOHN GAULE, *The Mag-Astro-Mancer*, London, 1652, p. 5. Cf. CARLETON, *op. cit.*, pp. 160-161.

(34) CARLETON, *op. cit.*, pp. 77-78; cf. ROWLAND, *op. cit.*, pp. 21-22. This suggestion had previously been made by the Church fathers.

(35) STUBBES, *op. cit.*, part II, p. 56; CHAMBER, *op. cit.*, p. 77; LUDOVICO VIVES, *An Introdvction to VVisedome*, London, 1544, ' Of the Mynde.'

Since we are men and Christians, argues AGRIPPA, we must not seek to know anything which is above our reach; we must confine ourselves to earthly things, and leave the hours and minutes to God who has put them in his own power. In other words, says PERKINS, to pay heed to this art or science is to withdraw our minds from the contemplation of God's providence, since by its precepts all things fall out by the disposition and motion of the stars (36). This consideration appears in PEELE's *David and Bethsabe* where DAVID warns SOLOMON not to wade too far in aspiring thoughts; he says that it is all very well to know the past but we should leave the future to God, calling upon Him in these words :

> Thou power,
> That now art framing of the future world,
> Know'st all to come, not by the course of heaven,
> By frail conjectures of inferior signs,
> By monstrous floods, by flights and flocks of birds,
> By bowels of a sacrificed beast,
> Or by the figures of some hidden art;
> But by a true and natural presage,...
>
> xv. 91-98.

The problem of free will assumed great proportions in the eyes of Elizabethan theologians and formed another basis for an attack upon astrology. This science, said the theologians, is clearly the work of the devil, since it permits men to impute their sins to the stars. THOMAS NASHE, for instance, assures the Londoners that their tribulations are due to the evil in the city, even though the astronomers (*i.e.* astrologers)

> Assigne it to the regiment and operation of the Planets. They say, *Venus*, *Mars*, or *Saturne*, are motiues therof, and neuer mention our sinnes, which are his chiefe procreatours. (37)

CALVIN, strangely, concurs in this conception. For will that one, he asks, who is persuaded that he is bound by necessity, because of his horoscope, ever call upon God? Will he ever commend his life to Him? Or if adversity befall him, will he impute it to his own sins? Again, CALVIN inquires, if he becomes prosperous, will he be anxious to sing God's praises?

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(36) AGRIPPA, *op. cit.*, p. 46; PERKINS, *op. cit.*, p. 40.

(37) THOMAS NASHE, " Christs Teares Ouer Ierusalem," *Works*, ed. A. B. GROSART, London, 1883-4, vol. IV, pp. 259-260.

These are also the feelings of STUBBES, GAULE, HOWARD, ROWLAND, and all others who wage war upon astrology (38). BEAUMONT and FLETCHER make use of this testimony in *The Fair Maid of the Inn* where Forobosco urges the Clown,

> Do not believe there is any such fetch in Astrology, and this may be the means to make us honest hereafter. V. i.

As we found previously, however, the astrologers agree with their adversaries that a belief in free will is a necessary doctrine for Christians, but assure us that their system does not dispose of it. Astrology, they insist, does not force men to do either good or evil; it merely inclines their natures. This belief is indicated by their much quoted phrase, *In virtute Dei sapiens dominabitur astris*.

If the devil were the originator of astrology, as those opposing the science insisted, it were quite logical that he should give some aid to its practitioners; and it followed that if the devil did aid astrologers, their science must be taboo. So it was that every adversary of astrology, whom I have encountered, admitted that the foreknowledge was often accurate, but explained that this was due to supernatural assistance. Indeed, the fact that horoscopes were often correct became, in effect, an actual argument against their use. This conception is explained clearly by CARLETON, who tells us,

> the cause why the Astrologer sometimes speaketh true, is not because hee seeth it in the Starres, as in naturall causes of that Euent... but because either by plaine compact, or else by a secret illusion of Satan, hee commeth to the knowledge thereof : which illusion may bee so great that the Astrologer may beleeue that hee readeth it in the Starres. (39)

So important does this principle become for CARLETON, that out of the ten chapters of his book, five (II, III, IV, VII, and IX) deal with it. Astrology, augury, black magic, etc., he insists, are all alike in this respect. That CARLETON's opinion on the similarity between astrology and black magic is a common one may be illustrated by the case of Doctor Faustus, in MARLOWE's play of that name. Early in this tragedy, Cornelius tells the protagonist,

(38) ROWLAND, *op. cit.*, pp. 49, 146-7, 180-1; STUBBES, *op. cit.*, p. 58; GAULE, *op. cit.*, ' To the Reader '; HOWARD, *op. cit.*, fol. 55; and CHAMBER, *op. cit.*, p. 10.

(39) CARLETON, *op. cit.*, p. 38; cf. pp. 23, 32, 37, 41, etc.

He that is grounded in Astrologie,
Inricht with tongues, well seene in minerals,
Hath all the principles Magicke doth require,...
ll. 167-9.

Later, as he is about to conjure, Faustus remarks,

Within this circle is *Iehouahs* name,
Forward and backward anagrammatiz'd
The breuiated names of holy Saints,
Figures of euery adiunct to the heauens,
And characters of signes and erring starres,
By which the spirits are inforst to rise,...
ll. 242-7.

Similarly, in his preface to the Christian reader, ROWLAND declares,

> we may easily perceive the clouds of *blasphemous opinions*, and *diabolicall practises* arise daily,... especially from the judgement, and practise of those subtill *Engineirs of Satan* ASTROLOGERS, whose religion is the same with *Jacob Behmens*, the *German-Conjurer*, as appears by Master Lilly's recommending his Works so highly for *Gospel light*, in one of his *Almanacks*. (40)

At the end of the century COTTON MATHER, in America, held the same objection to astrology, pronouncing it to be unlawful since it lay midway between magic and quackery, and partook not a little of the nature of each (41). These considerations, it may be added, are entirely historical, coming directly from ORIGEN, and from ST. AUGUSTINE (*De Civitate Dei*, V. 27) (42). FRANCIS COXE, however, makes an addition to the historical argument when he testifies that the insidious thing about astrology is the effect it has upon its practitioners. There never was any man, says COXE, who could be contented with a simple knowledge of astrology; he must always delve further and further into the sciences of prediction, using this doctrine as a ground to work to far higher matters (43). The inference, of course, is that astrology here serves merely as an entering wedge for the more enticing studies of foreknowledge belonging to black magic.

(40) ROWLAND, *op. cit.*, ' To the Christian Reader '; cf. pp. 123 ff., 132, 134, 189, 239, 306.

(41) COTTON MATHER, *Wonders of the Invisible World*, Boston, 1693, p. 124.

(42) HOWARD, *op. cit.*, fol. 105; and CHAMBER, *op. cit.*, p. 95. For other references to the belief that astrologers had supernatural aid, see MARBECK, *op. cit.*, pp. 78-80; PERKINS, *op. cit.*, pp. 40-41; AGRIPPA, *op. cit.*, p. 49; MELTON, *op. cit.*, p. 43; STUBBES, *op. cit.*, p. 63; and CHAMBER, *op. cit.*, pp. 41, 95.

(43) COXE, *op. cit.*, sig. A6v.

Indeed, this is borne out by the case of Doctor Faustus. We must not forget, however, that COXE made his confession under duress.

The only remaining argument of any consequence is the charge that astrologers for the most part were tricksters. In speaking of astrologers, for example, REGINALD SCOT asserts,

> though there be many of them learned and godlie, yet lurke there in corners of the same profession, a great number of counterfets and couseners. (44)

When we consider the records of such men as Doctor FLUDD, SIMON FORMAN, EDWARD KELLY, JOHN LAMBE, etc., it must be admitted that there is a certain amount of truth in this contention.

There are two particular reasons why astrology should have lent itself so easily to charlatanry. In the first place, this science was surrounded with an aura of mystery. To the average Elizabethan, it seemed little short of miraculous that any man should understand the stars and their relations to each other, to such an extent that he could read future with their aid. Even the very terms of astrology were mystifying. LYLY's astrologer, in *Gallathea*, speaks the typical language of the spurious practitioner as he explains his ability to Raffe, his servant :

> I can tell the minute of thy birth, the moment of thy death, and the manner. I can tel thee what wether shall be betweene this and *Octogesimus octauus mirabilis annus*. When I list I can sette a trap for the Sunne, catch the Moone with lyme-twigges, and goe a batfowling for starres. I can tell the things past, and things to come, & with my cunning, measure how many yards of Clowdes are beneath the Skye. Nothing can happen which I fore-see not; nothing shall. (45)

Raffe later twits Robin for serving an alchemist, saying that his master is more learned :

Raffe : I shoulde haue halfe a dozen starres in my pocket if I haue not lost them, but heere they be. *Sol, Saturne, Iupiter, Mars, Venus.*

Robin : Why these be but names.

Raffe : I, but by these he gathereth, that I was a ioualist, borne of a Thursday, & that I should be a braue Venerian, and gette all my good lucke on a Fryday.

Robin : Tis strange that a fishe day should be a flesh-day.

Raffe : O Robin, *Venus orta mari*, Venus was borne of the Sea, the Sea will haue fishe, fishe must haue wine, wine must haue flesh, for *Caro carnis genus est muliebre* :...

(44) *The Discoverie of Witchcraft*, London, 1584, p. 171.

(45) See *Gallathea*, III. iii. 34-85, for the whole passage. Cf. NASHE, 'Terrors of the Night,' *op. cit.*, vol. III, pp. 247-8.

Raffe, however, is not quite so gullible as he seems, for a little earlier he tells us that his master, while delivering talk upon conjunctions, fell backward into a pond; when Raffe asked why this misfortune was not foretold by the stars, the astrologer replied that he knew it would happen, but contemned it. This passage is reminiscent of Sir THOMAS MORE's epigram in which the astrologer is asked why all things are not known to him :

> To thee thou airie Prophet all
> the Starres themselues do showe :
> And do declare what destinies,
> all men shall haue bylowe.
> But no Starres (though they all thinges see)
> admonish thee of this :
> That thy wife doth with erie man,
> behaue her selfe amisse. (46)

In the second place, the intricacies of the science offered many loop-holes in case an inaccurate prognostication were made. There might have been an error in recording the moment of birth. Perhaps a miscalculation had been made when the places of the planets were noted in the ephemerides. Many other mistakes might have crept in. But even if all these data were correct, asserts AGRIPPA, the astrologers cloak one lie with another saying that since the wise man rules the stars, he may have avoided a predicted accident (47). Incorporating this tendency toward trickery, Melton gives a new definition of astrology :

> Astrologie is an Art, whereby Cunning Knaues cheat plaine honest Men, that teacheth both the Theory and Practicke of close Cousenage, a Science instructing all the Students of it to lye as often as they speake, and to be beleeued no oftener than they hold their Tongues; that tells truth as often as Bawds go to Church, Witches or Whores say their Prayers, or neuer but when the *English* Nones and the *Greeke* Calends meet together. (48)

ROWLAND's feeling about the entire matter is that the abuse of astrology should prohibit its use, especially since the science is unnecessary (49). So many people flock to the astrologers

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(46) From AGRIPPA, *op. cit.*, pp. 47-47a. Cf. MELTON, *op. cit.*, p. 24, who mentions a similar case.

(47) AGRIPPA, *op. cit.*, p. 46.

(48) MELTON, *op. cit.*, pp. 22-23; cf. ROWLAND, *op. cit.*, pp. 173-4.

(49) *Ibid.*, p. 9.

to be gulled, concludes SAMUEL BUTLER, that (as with lookers-on who enjoy a juggler) there must be as great pleasure in being cheated as in cheating (50).

The best extended example in literature of the spurious astrologer in action, is found in the play *Albumazar* by THOMAS TOMKIS (or TOMKINS), presented before the king at Cambridge on March 9, 1614. It was printed in 1615, 1634, and 1668, DRYDEN writing the prologue to the last named edition. The story is as follows: Pandolfo, an elderly gentleman, is in love with the daughter, Flavia, of his old friend Antonio; Antonio (now thought to be dead) had been in love with Pandolfo's daughter, Sulpitia; and these two old men agree to marry each other's daughter. Flavia, however, is in love with Pandolfo's son, Eugenio; while Sulpitia is in love with Antonio's son, Lelio. Even though Antonio is supposed to be dead, Pandolfo still hopes to carry out his part of the bargain and marry Flavia; but she will not have him. He consults Albumazar, a clever charlatan who uses astrology as a background for his thievery. Albumazar assures Pandolfo that he can change one man into another, and that he will use this power in inducing the children to believe that Antonio has returned. Pandolfo now persuades a servant to submit himself for the transformation. The change is to take place in one of Pandolfo's rooms which has been entirely filled with his treasure. Needless to say, Albumazar and his thieves steal all the treasure, tie up the servant, and escape. Meanwhile the real Antonio turns up, only to be taken by Pandolfo as the transformed servant. The trouble is cleared up when Albumazar confesses to the trickery because the other thieves have refused to give him his share of the booty. The play ends with the youngsters in the arms of their sweethearts, while Pandolfo and Antonio decide that they are too old to marry (51).

Although this play is quite clearly an academic satire upon astrology, there are at least two passages in which the author

(50) BUTLER, *op. cit.*, p. 152.

(51) THOMAS TOMKIS, *Albumazar*, London, 1615; reprinted in DODSLEY'S *Old English Plays*, ed. W. C. HAZLITT, London, 1875, vol. XI, pp. 291-421. This play is undoubtedly an English version of BATTISTA DELLA PORTA'S *L'Astrologo*, Venice, 1606; cf. the note to page 301 of *Albumazar*, and the *D.N.B.*

XUM

vouches for a legitimate practice of the science. When, early in the play, Pandolfo's servant is finally convinced that Albumazar is a real astrologer, he says to his master,

> In earnest, sir, I took him for a cheater;
> As many, under the name of cunning men,
> With promise of astrology much abuse
> The gaping vulgar, wronging that sacred skill,
> That in the stars reads all our action.
>
> p. 326.

Again, Antonio rejoices thus at his safe return :

> Thus, by great favour of propitious stars,
> From fearful storms, shipwreck and raging billows,
> [And] merciless jaws of death, am I returned... (52)
>
> p. 376.

With these views before us, perhaps it will be interesting to examine JOHN MELTON'S *Astrologaster* for the excellent description of a contemporary astrological trickster contained therein. A friend had related to MELTON an account of how he was duped by a mountebank, and the author decided to visit a star-gazer to see for himself. To this end he called upon one ' Doctor P. C. ' for a consultation. Entering the house, MELTON found the charlatan sitting before

> a Square Table, couered with a greene Carpet, on which lay a huge Booke in *Folio*, wide open, full of strange Characters, such as the *Aegyptians* and *Chaldeans* were neuer guiltie of; not farre from that, a siluer Wand, a Surplus, a Watering Pot, with all the superstitious or rather fayned instruments of his cousening Art. And to put a fairer colour on his black and foule Science, on his head hee had a foure-cornered Cap, on his backe a faire Gowne (but made of a strange fashion) in his right hand he held an Astrolabe, in his left a Methematicall Glasse. (53)

After many bows, the author explained that the purpose of the visit was to locate a gold chain of three hundred links which he had lately lost. MELTON then ' greased his euer-dry Palmes with an Angell,' and received the following effusion :

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(52) For other literary expressions against astrology, see CYRIL TOURNEUR, *The Atheist's Tragedy*, V. i.; *Julius Caesar*, I. ii. 140-1; *Lear*, I. ii. 113-26. This last is Edmund's soliloquy beginning, ' This is the excellent foppery of the world,' concerning which passage, Professor HARDIN CRAIG sets forth the interesting theory that his denial of the influence of the heavens ' must be meant to indicate his denial of religion '; (' The Ethics of King Lear,' *Philological Quarterly*, IV (1925), p. 104.)

(53) MELTON, *op. cit.*, p. 8.

Honest Friend, the losse you haue sustayned, is so great, that I make no doubt, what you now haue giuen, or hereafter shall giue, will not come forced or wrackt from you, but voluntarie and free. For it is wisdome in a Man to aduenture small things to regayne greater, where there is a possibilitie of obtayning. He is not worthy of Money, that will not seeke after it, and he cannot truly iudge, how to value so precious a Metall as Gold, that is not stung with the losse of it. Therefor Sir, your care deserues a redresse, and this Booke (meaning his *Ephimerides*) with my Art and Industrie, shall be the Instrumentall Causes to make you happie in the recouerie of that which is worthie both of my Care and your Cost. (54)

The author replies to this exordium, telling the astrologer that such a speech was delivered only to make a fool of the consultant and to urge him on to cheat himself. From this point onward, the book is taken up with MELTON's castigation of astrology, all of which, of course, is delivered to the Charlatan. MELTON asks this man why it is, if astrology be a science or an art, that its practitioners are forced to flee to such by-places, dark corners, and garden alleys. The only possible answer, believes MELTON, is either that the astrologers wish to escape the eye of the world so that their trickery will not be discovered; or that they wish to be thought more learned in the eyes of the ignorant, who suppose that melancholy places are consonant with such a study. Continuing in the same vein, the author declares that the astral science is unlawful, and that its students are damnable and diabolical; his arguments are similar to those which we have considered above. As MELTON finishes his harangue, the officers arrive, seize the astrologer ' for cousning a poore Grasier of fiueteene pound,' and thus the book ends (55). We must not forget, however, that this astrologer was not a legitimate practitioner, as were others. This man, for example, had a crystal in which he maintained he could see everything happening in the world; he likewise practiced alchemy, a science which fed not only on the gullibility of the public, but on its avarice as well.

There is in Elizabethan literature a similar case of an astrological consultation, which is recorded in one of ROBERT GREENE's *Conny-Catching* pamphlets. The story in part is as follows: A broker cheated a tailor out of a purse and other goods, and

(54) *Ibid.*, p. 9.
(55) *Ibid.*, pp. 15, 21, 23, 79-80, etc.

XUM

was in turn tricked by a cony-catcher. The latter, who of course knew that the stolen property was in the possession of the broker, was finally consulted by the tailor, who wished to have the goods returned. The cony-catcher assured him that he would, by his art, work the recovery thereof; whereupon

> he drew foorth a litle booke out of his bosom,—whether it were latin or english it skilled not, for he could not read a worde on it,—then desiring them to spare him alone a while, they should perceiue what he would do for them... and not long had they sitten absent out of the roome, but he called them in againe, and seeming as though he had bin a scholler indeed, said he found by his figure [*i.e.* horoscope] that a Broker in such a place had their goods lost, and in such a place of the house they should find it,... (56)

Part Two

THE ATTITUDE OF THE ADVOCATES

Popularity

In Part One of this paper we found that the chief arguments against astrology were theological. In Shakespeare's day, of course, objections of this nature against science were accepted as valid. What, then, could the astrologers propose that would mitigate an opposition of this sort? There were many things. Besides the fact that every argument advanced against it was fully answered by its proponents, perhaps the principal reason for the acceptance of astrology was its unchanging popularity. People had always believed in it; why should they not believe in it now? Astrology was thoroughly in the medieval tradition, and no new proposal had invalidated it (57). Practically every court in

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(56) Robert Greene, 'The Third Part of Conny-Catching,' *op. cit.*, vol. X, pp. 185-192.

(57) Cf. C. M. Hathaway's edition of *The Alchemist*, New York, 1903, p. 37. Harold V. Routh (*Cambridge History of English Literature*, VII, p. 427) states that astrology would have died out in the fifteenth century if the people had not lost their track amid the dangers and difficulties of intellectual progress, and turned backward in search of their way. All of this sounds very well, but I can find no factual basis for such a statement. In the first place, Mr. Routh seems to have accepted uncritically the usual theory of the Renaissance. Besides this, however, how is it possible to intimate that there was any retrocession? At

Europe at this time had astrologers in its employ, and most courtiers were eager votaries of the practice of this science (58). Concerning the popularity of astrology in the Elizabethan period, ZOUCH says,

> Its predictions were received with reverential awe; and even men of the most enlightened understanding were inclined to believe that the conjunctions and oppositions of the planets had no little influence on the affairs of the world. (59)

HENRY VII is reported to have directed his Christmas keeping by means of the stars. HENRY VIII's physicians made no diagnosis without astral consultations; HENRY, too, made use of the science in many ways (60). It was Queen ELIZABETH and her famous astrologer, JOHN DEE, however, who did more than any other person to popularize astrology. Under them it became more or less of a court fad. DEE had already cast the horoscope of Queen MARY when she succeeded her brother in 1553. Soon afterward he performed the same honor for ELIZABETH. Later he was called upon to set a figure and determine the most auspicious day for the Queen's coronation. Because of these royal honors bestowed upon DEE, many famous people asked him to cast their nativities (61).

This science, further, was taught in many universities of the day. In the sixteenth century there is an instance at Oxford of a Scholar's being admitted 'To practice in astrology.' A general grace for Regents in Arts is also recorded in the same institution, 'Quod si contingat aliquem eorum studere in astronomia possit practicare in eadem' (62). Similarly, astrology formed a part of the regular training of the physician during this period, as

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no time had a belief in this science decreased. Indeed, a glance at Professor LYNN THORNDIKE's recent book *(Science and Thought in the Fifteenth Century)* will show that an increasing number of astrological works were being written.

(58) Cf. E. B. KNOBEL, 'Astronomy and Astrology,' *Shakespeare's England*, I, p. 456; and CHARLOTTE FELL-SMITH, *John Dee*, London, 1922, p. 32.

(59) ZOUCH, *Walton's Lives*, London, 1796, p. 113, note.

(60) JOHN CHAMBER, *A Treatise against Iudicial Astrologie*, London, 1601, p. 29.

(61) Recorded in his diary, Camden Society, vol. XIX, London, 1842. Cf. FELL-SMITH, *op. cit.*, p. 14; HATHAWAY, *op. cit.*, p. 34; R. STEELE, 'Magic and Alchemy,' *Social England*, New York and London, 1895-96, IV, p. 87.

(62) HASTINGS RASHDALL, *The Universities of Europe in the Middle Ages*, Oxford, 1895, II, pp. 458-459.

XUM

I have indicated elsewhere (63). Indeed, astrology was recognized as one of the seven liberal arts (64).

To attest further the prevalent belief in the efficacy of astral predictions, we have only to consider the large number of books published on this subject. And G. B. HARRISON remarks that books on witchcraft, alchemy, and astrology were always sure of a public (65). Then too, type for the various astrological signs of the zodiac, planets, etc., was contained in the fonts of all printing houses (66).

Perhaps the most conclusive proof of the extensive popularity of this science is the rather remarkable number of passages in the contemporary drama, in which astrology is mentioned in a casual way. In CHAPMAN's *Byron's Conspiracy*, for example, La Brosse says to himself,

> This hour by all rules of astrology
> Is dangerous to my person, if not deadly.
> How hapless is our knowledge to foretell,
> And not be able to prevent, a mischief:
> O the strange difference 'twixt us and the stars;
> They work with inclinations strong and fatal,
> And nothing know; and we know all their working.
> And nought can do, or nothing can prevent.!
>
> III. i. 1-8.

This view, however, is not the actual attitude of the astrologers. They do not say that men are unable to prevent the working of the planets; on the contrary, they say that the wise man rules the stars. In the same play, La Brosse tells Byron that tragedy awaits him, and receives this reply:

> Spite of the stars and all astrology
> I will not lose my head; or if I do
> A hundred thousand heads shall off before.
> I am a nobler substance than the stars,
> And shall the baser overrule the better?
>
> III. i. 106-110.

Byron continues for some lines in this vein, berating the influence

(63) 'Elizabethan Astrological Medicine,' *Annals of Medical History*, New Series, II (1930), pp. 217-226.

(64) ROUTH, *op. cit.*, p. 427.

(65) G. B. HARRISON, 'Books and Readers, 1591-94,' *The Library*, VIII (1927 p. 291.

(66) Cf. reproduction of MOXON's *Mechanick Exercises* in R. B. MCKERROW *Introduction to Bibliography*, Oxford, 1927, p. 9.

of the stars. The surprising thing in this play, is that CHAPMAN proves the astrologer to have been right, since Byron dies as was predicted, but not before admitting defeat :

> What have I done to shun the mortal shame
> Of so unjust an opposition,
> My envious stars cannot deny me this,
> That I may make my judges witnesses
> And that my wretched fortunes have reserv'd
> For my last comfort :
>
> V. ii. 201-206.

MARLOWE, too, makes use of this science in many places. As death draws near, Faustus speaks thus :

> You stars that raign'd at my natiuitie,
> Whose influence hath alotted death and hel,
> Now draw vp Faustus like a foggy mist,...
>
> 1443-1445.

Achates, in *The Tragedy of Dido*, urges Aeneas to forget the queen :

> Banish that ticing dame from foorth your mouth,
> And follow your foreseeing starres in all;...
>
> 1181-1182.

In lamenting the fact that his gold and his house are to be taken, Barabas shouts,

> You partiall heauens, haue I deseru'd this plague?
> What will you thus oppose me, lucklesse Starres,
> To make me desperate in my pouerty?
>
> *Jew of Malta*, 494-496.

Tamburlaine believes that the stars have promised him the Persian crown; and when using Bajazeth as a foot-stool, he says,

> Smile Stars that raign'd at my natiuity :
> And dim the brightnesse of their neighbor Lamps,...
>
> *Tamburlaine I*, 1477-84.

Cosroe, in the sequel to this play, realizes that Tamburlaine's stars are favorable, as does the enemy king, Theridamas, who laments thus :

> Weepe heauens, and vanish into liquid teares,
> Fal starres that gouerne his natiuity,... (67)
>
> *Tamburlaine II*, 4393-4.

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(67) Other passages in MARLOWE are : *Tamburlaine I*, 286-8; *Edward II*, 1929-30; *Doctor Faustus*, 911-15.

PEELE's casual references are numerous. In the *Battle of Alcazar*, Calipolis tells the Moor :

> Such secret judgments have the heavens imposed
> Upon the drooping state of Barbary,
> As public merits in such lewd attempts
> Have drawn with violence upon our heads.
> II. iii. 66-69.

In the same play King Sebastian warns Stukely how impossible it will be to attack Ireland because that country is ruled by England :

> T' invade the island where her highness reigns,
> 'T were all in vain, for heavens and destinies
> Attend and wait upon her majesty.
> II. iv. 106-8.

In this play, again, both the Moors and their opponents believe in the power of the stars. *Edward I* seems to be even motivated by a belief in astrology; Lluellen, the Mayoress, Sir David, Elinor, and Edward all express their acceptance of the tenets of this science. In the *Arraignment of Paris*, Jupiter addresses Paris thus, after the trial :

> Shepherd, thou hast ben heard with equity and law,
> And for thy stars do thee other calling draw,
> We here dismiss thee hence, by order of our senate : (68)
> IV. i. 195-7.

In LYLY's *Endimion*, Cynthia asks Semele what causes her sharp tongue :

> Is it destinie, or deceit that hath brought this to passe?
> If the first, who could preuent thy wretched starres? (69)
> IV. iii. 76-7.

The Fair Maid of the Inn contains the following passage spoken by Alberto to Mentivole :

> Thou tak'st me in an ill Planet, rash young man,
> And hast cause to curse thy Father.
> II. i.

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(68) Other references in PEELE are : *Battle of Alcazar*, V. i. 26-7, V. i. 171-2, V. i. 73-84, V. i. 122-3; *Edward I*, x. 262-3, v. 112-3, i. 100-192, xix. 11-12, xxiv. 8-11, xvii. 1-3; *David and Bethsabe*, ix. 11-12, xii. 8-10, xv. 76-8; *Arr. of Paris*, II. i. 54-7, III. ii. 74-5.

(69) Other passages in LYLY are : *Sapho and Phao*, I. i. 8-10; *Woman in the Moon*, V. i.; *Midas*, IV. i. 1-2; many other passages have been mentioned elsewhere.

And immediately before the murder, Melantius *(The Maid's Tragedy)* remarks,

> This is a night, spite of astronomers,
> To do the deed in.
> IV. ii. 288-9.

Numerous astrological terms are used in plays, as well. Vilarezo (*The Maid's Revenge*, V. iii) tells Catalina, 'I am planet-struck,' meaning that he suffers from an evil aspect of a planet. Tigranes (*King and No King*, I. i. 152-3) says to Arbaces,

> Though this be worse
> Than that you spoke before, it strikes me not;

this passage has a similar meaning. In *The Custom of the Country*, Jaques makes a lewd reference to the taking of astrological readings by means of the astrolabe, when he refers to the Frenchman and his profession :

> Alas, he's all to fitters,
> And lies, taking the height of his fortune with a syringe ! (70)

The popularity of astrology is further indicated by the men who gave credence to the science. By far the most famous advocate was JOHN DEE, the Queen's astrologer, who was born in London in 1527. He was educated at St. John's College, later became a fellow of Trinity, still later warden of Manchester College, and finally warden of Christ's. Having spent two years lecturing and studying at Louvain and Rheims, he returned to England in 1551, when he received a pension from EDWARD VI. In 1578 he was sent abroad to consult with German physicians and astrologers about the Queen's health. The years 1583-89 found him in Poland and Bohemia under the patronage of ALBERT LASKI, the palatine of Siradez. Although DEE was very popular with the Queen, and received many marks of favor from her, his star declined after her death. His own end came in 1608 at the age of 81, in a state of dire poverty.

JOHN DEE wrote on many subjects such as navigation, history,

(70) III. iii. 4-5. For other general references, cf. SHIRLEY's *The Maid's Revenge*, III. ii; TOMKIS' *Albumazar, op. cit.*, pp. 320-321; CHAPMAN's *Byron's Conspiracy*, I. i. 174-6; *The Longer Thou Livest, the More Foole Thou Art*, ll. 1366-71; *All for Money*, ll. 22-28; GREENE's *Frier Bacon and Frier Bungay*, ll. 1602-9.

logic, travel, geometry, astrology, heraldry, genealogy, and many others; but his greatest contribution to science, perhaps, is his books and lectures on EUCLID's mathematical prefaces. Another interesting book by this author is the *Stenographia of Trithemius* which seemed to deal with magical conjurations. But eighteenth century critics discovered it to be a manual of cryptograms for the conveyance of secret information. This fact has led R. STEELE to the conclusion that DEE's many journeys to the continent 'covered other secrets than alchemical ones.' It is believed that he was one of ELIZABETH's valuable political agents, and that his letters to WALSINGHAM were in the nature of a spy's reports. On one of his continental excursions, DEE received a flattering offer from the Emperor of Russia, FEODOR IVANOVITCH, to become a member of his court. This offer was to include 2,000 pounds yearly and free diet from the royal kitchen. DEE's dealings with EDWARD KELLY have always been interesting, for in KELLY we had the true charlatan who gulled every-one, even his friend DEE. DEE considered KELLY to be his 'scryer,' and is supposed to have learned many occult matters from him. KELLY's chief interest, however, was in alchemy, by means of which he robbed kings and princes all over Europe. These practises finally cost KELLY his life (71).

Because of DEE's connection with astrology, the many friends of this man become especially interesting. DEE was very intimate with THOMAS DIGGES (son of LEONARD, who is remembered for his almanacs), 'the first English mathematician of the day.' When JEROME CARDAN came to England in 1552, he lodged at Sir JOHN CHEKE's house where DEE must surely have consulted with him. CARDAN, we remember, is usually spoken of as the foremost astrologer of the time; although a practitioner of this science, he was not at all a credulous man, having confidently pronounced witchcraft to be a form of insanity. JOHN CHEKE (called by STEELE 'the most learned man in England') was an amateur astrologer who had many connections with DEE; he was the man who introduced DEE to Secretary CECIL and

(71) FELL-SMITH, *op. cit.*, pp. 60-61, 168-9, 176-7, 269; *Encyclopaedia Britannica*; HATHAWAY, *op. cit.*, p. 44; R. STEELE, 'Magic, Astrology, and Alchemy,' TRAILL's *Social England*, London, 1895-6, III, p. 330.

EDWARD VI, and was responsible for DEE's first government pension. Another friend, ROBERT DUDLEY, commanded DEE to name an auspicious day for the coronation of ELIZABETH at Westminster Abbey. The Earl of PEMBROKE was also an early sponsor of this astrologer. STOW, the chronicler, is spoken of as DEE's 'loving friend.' The diary for January 16, 1577 records the visit of PHILIP SIDNEY, the Earl of LEICESTER, and EDWARD DYER; the latter was a friend of SIDNEY's who was associated with DEE and KELLY in their alchemical experiments. One of DEE's children had as godfather Sir GEORGE CAREW, and as godmothers, Lady COBHAM and Lady WALSINGHAM. On May 22, 1592, DEE wrote 'To the Worshipfull my singular friende Mr. CAMDEN' apropos of his son's (ARTHUR's) return to school; here he says,

> The naturall inclination is to me evident; as who hath ☉ in horoscope, and ♃ in corde Leonis. *Dictum sapienti sat esto:* for *vera curatura* you may alter this naturall courage to true fortitude and not to frayle rash fancyes: Socrates did overcome by grace Divine and his industrie, his untowardness, signified by the Art physiognomicall—you know the historie. (72)

The Countess of WARWICK, too, secured from the Queen a promise that Dee should have the mastership of St. Cross at Winchester; and the Archbishop of Canterbury asserted that this benefice was eminently right. Archbishop WHITGIFT was DEE's friend and petitioner; Dr. WILLIAM AUBREY, the Master of Requests, gave him much assistance; Lord WILLOUGHBY, Countess of KENT (WILLOUGHBY's sister), MICHAEL PEISER (doctor to the Duke of BRANDENBURG), JOHN ASKE, and Sir THOMAS WILLES were frequent visitors to DEE's home. Sir THOMAS WILLES was also quite intimate with the famous ROBERT RECORDE, who was something of an astrologer, and in 1582 he edited and augmented this latter author's *The Ground of Artes*. DEE's friendship for the great sea captains, the GILBERTS, DAVIS, HAWKINS, FROBISHER, Sir WALTER RALEIGH, and others, is also a matter of record. While in Bremen, DEE mingled with many of the most distinguished and learned men of the time.

(72) FELL-SMITH, *op. cit.*, pp. 227-8; cf. pp. 13, 18, 19, 30, 32, 36, 37, 38, 67-8, 99, 216, 217, 220, 225, 226, 241, 251, 258, 303; JOHN DEE, *Private Diary*, London, 1842 (Camden Soc., XIX), pp. 4, 26, 38, 43, 44; and G. M. HORT, *Dr. John Dee*, London, 1922, pp. 23-4.

Dr. CHRISTOPH PEZEL, professor of divinity and superintendent of the churches at Bremen, paid him much honor, and composed some verses on his departure, which were printed and distributed on that event. Sir WILLIAM STANLEY, the Deputy Governor of Stade, Dr. HEINRICH KHUNRATH (the learned doctor, alchemist, and mystic of Hamburg), and other famous individuals visited him on this occasion. JOHN DEE, therefore, at home and abroad was recognized as one of the leading figures in court and learned circles. In his diary are found the names of many well-known Englishmen who visited him in order to have their horoscopes cast and read.

One of the most interesting men of the Elizabethan period, and one who dabbled in astrology, is ROBERT BURTON, the author of *The Anatomy of Melancholy*. In this book, he gives an instructive account of the subject, recording various cases in which predictions have come true, as well as arguments for a belief in the science. In his address to the reader he says,

> Saturn was the Lord of my geniture, culminating etc. Mars the principal significator of manners, in partile conjunction with mine Ascendant; both fortunate in their houses, etc. (73)

He later adds, 'I had Jupiter in my Sixth House.'

We have indications of other men who accepted the tenets of this science. JOHN SOOUTHERN's *Pandora*, for example, is dedicated to the Earl of OXFORD in the following words:

> For who maketh better than he
> The seven turning flames of the sky? (74)

This statement seems to show that OXFORD had studied astrology. Dr. RICHARD FOSTER was president of the College of Physicians, 1601-4, and yet had compiled an almanac and prognostication for 1571. JOHN DAVIES of Hereford seems to indicate a belief in astral predictions in his epilogue on the deaths of GEORGE WHARTON and JAMES STEWARD:

> The eye of heauen did rowle the house about
> Of that fell twi-formed Archer (75) at the time
> That this faire-feller accident fell out;...

(73) ROBERT BURTON, *The Anatomy of Melancholy*, ed. A. R. SHILLETO, London, 3 vols. 1896, vol. I, p. 14; cf. p. 37.

(74) This reference was given me by Professor BALDWIN MAXWELL.

(75) (DAVIES' note) 'The 9th of Nouv. the sun approaching the signe of Sagitarius.' Cf. WORKS, ed. A. B. GROSART, 2 vols., Edinburgh, 1878, vol. II, ep. 125

Perhaps it will be remembered that HENRY HOWARD, the Earl of Northumberland, wrote *A Defensatiue against the poyson of supposed Prophecies*, in which astrology in general is attacked. The singular thing about him is that there are at least two reasons for thinking that he looked with favor upon astrology. In the first place, AUGER FERRIER'S *Learned Astronomicall Discourse, of the Iudgement of Natiuities* was dedicated to him in 1593, *i.e.*, ten years after his own attack. In the second place, PEELE in the prologue to *The Honour of the Garter*, speaks of HOWARD as understanding many things; he has, for example,

> That admirable mathematic skill
> Familiar with the stars and zodiac,
> To whom the heaven lies open as her book;... (76)

CHRISTOPHER HEYDON mentions one FLETCHER of Caius College, as an astrologer. And when DARIOT'S work was revived by N. SHARP in 1653, it was dedicated to GEORGE ATWELL, a mathematician of Cambridge. It may be added in passing that Cambridge seemed to look more kindly upon astrology than did Oxford; FULKE, FLEMING, DEE, etc. attended or were graduated from this university.

From other countries the names of TYCHO BRAHE, KEPLER, and JEAN BODIN come to us. BODIN attributed CAESAR'S success to the belief that at the crisis of his fate there was a great conjunction of the superior planets in Scorpio; he also listed the series of disasters that had occurred whenever the sun entered Libra (77). TYCHO BRAHE is said to have taken the horoscope of RUDOLPH II. BRAHE was a perfect son of the sixteenth century believing, as DREGER puts it,

> the universe to be woven together by mysterious connecting threads which the contemplation of the stars or of the elements of nature might unravel, and thereby lift the veil of the future. (78)

WILLIAM HABINGTON, writing in 1634, speaks of him in these words,

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(76) 'Ad Maecenatem Prologus,' ll. 8-10. I have discussed HOWARD'S life of intrigue in the paper on almanacs, *op. cit.*

(77) Cf. *Tudor Studies*, ed. R. W. SETON-WATSON, London, 1924, p. 121.

(78) Cf. LYNN THORNDIKE, *The Place of Magic in the Intellectual History of Europe*, New York, 1923, p. 22.

XUM

Learned shade of Tyche Brahe, who to us,
The stars propheticke language didst impart,
And even in life their mysteries discuss :
Castara hath o'erthrowne thy strongest art. (79)

Along with the legitimate practitioners of astrology, there were, as is always the case, many quacks, some of whom were famous. DEE's associate, EDWARD KELLY, is castigated by JOHN DAVIES of Hereford in his epigram ' Of Plasmus the Alchymist :'

Plasmus the poore and bare Gymnosophist,
Contemplates of the sunne, the moone and starres;
Besides he is a perfect Alchymist;
He makes th' elixer which so many marres;
Ripley and Kelly of his skill did faile
Yet scarce he hath one ragge vpon his taile. (80)

JOHN LAMBE was another well-known rascal who seems to have been admired in some circles for his great skill in magic and astrology. As a youth he was a tutor, but lighting upon an even easier way to make money, he became addicted to the arts named above. In 1608 he was convicted of practicing magic, and imprisoned in King's Bench Prison in easy confinement for fifteen years. LAMBE's fame spread, however, and he received clients in prison. He is supposed to have had an evil influence upon the Duke of BUCKINGHAM, to whom he owed his lenient treatment while in prison. LAMBE was mobbed in June 1628, and the duke was assassinated on August 23rd of the same year, with the people crying,

Let Charles and George do what they can,
The Duke shall die like Dr. Lambe. (81)

Another popular charlatan was SIMON FORMAN, an astrologer and quack doctor. In 1579 he discovered that his accidental predictions were being realized, and began to practice in earnest immediately afterwards, coming to London in 1583. In 1603

(79) WILLIAM HABINGTON, *Castara*, ed. ARBER, Westminster, 1895, p. 26. Cf. GEORGE FORBES, *The History of Astronomy*, N. Y., 1909, p. 47; O. J. THATCHER, *The Ideas that have Influenced Civilization*, Milwaukee, 1901, p. 308. One of BRAHE's interesting books, which I have examined, is the *Astronomiae Instauratae Mechanica*, Noribergae, 1602.

(80) JOHN DAVIES of Hereford, *op. cit.*, ep. 61.

(81) Cf. *Dictionary of National Biography*; and C. J. S. THOMPSON, *The Quacks of Old England*, Philadelphia, 1929, pp. 37-9.

he was made an M. D. of Cambridge. During his active life he was brought before the College of Physicians and imprisoned many times. FORMAN was not only a quack, but a scoundrel as well; his treatment of women patients is recorded as being most unprofessional. He left a large illegitimate family. It is said that at one of FORMAN'S trials the prosecuting attorney began to read a list of the women with whom FORMAN had *affaires de cœur*, when suddenly he stopped short,—he had discovered his wife's name (82).

Dr. ROBERT FLUDD is another physician who practiced astrology. He was born in 1574, educated at St. Johns College, Oxford (A.B. 1596, M.A. 1598), and Christ Church (M.B. and M.D., 1605). In 1609 he was made a Fellow of the College of Physicians, and was a censor of the College in 1618, 1627, 1633, and 1634. Although FLUDD seems to have been well trained, this did not deter him from taking a great interest in rosicrucianism and other mystic philosophies. The author of the article about him in *The Dictionary of National Biography* says,

> As a writer, Fludd is the chief English representative of that school of medical mystics which laid claim to the possession of the key to universal science.

In reply to a charge by one FOSTER that he was a magician, FLUDD published *Doctor Fludds answer unto M. Foster*, in 1631. Herein he defends astrology, as well as himself:

> I would therefore haue our Sponge-bearing aduersary know, that there are foure parts or kinds of Astrology in generall—the first is conuersant about the mutation of the aire, & foretelling of tempests, diseases, famine, or plenty, etc. The second foretelleth the alterations of states, also wars, or a pacifick disposition in the minds of men. The third intreateth of the election of times, and of natiuities. The last is directed vnto the fabricating of characters, seales, and Images, the which, because it mingleth itself with superstitious actions, & is made an instrument for the abuses of impious persons; and especially because a diabolical insinuation vnto vice and impiety, may easily be perceiued in it, is of all good Christians to be repudiated and condemned for vnlawful. What? Is the Almanack makers Science for this *Mr. Fosters* exception, to be put downe, or must Physicians be forced to forsake or neglect their houres of election, in gathering of simples, or letting blood, or cutting the hayre and nailes, or stopping laxes, or making the belly lubricke for this mans caueat? (83)

(82) *Dictionary of National Biography;* THOMPSON, *op. cit.*, p. 31; STEELE, *Social England*, IV, p. 87.

(83) P. 134. FRANCIS BACON makes a similar statement about magical astrology involved in the making of seals, images, etc. (Cf. *Advancement of Learning*, *Works*, Bohn Library, London, 1894, book III, chapter iv, p. 133.)

XUM

General Attitude

The usual feeling about astrology during the Elizabethan period is that it is the most useful of the sciences. It is the end, says Vincentius, towards which all clergy work,

> And who knoweth wel and vnderstandeth astronomye, he can settle reson in alle thinges;... ffor it is the science aboue alle other by whiche all maner of thynges ben knowen the better.

Again he asserts,

> Ffor ther is nothynge withyn the erthe ne withyn the see, how dyuerse it be, but it is on the heuen fygured and compassed by the sterres,... (84)

In Stephen Hawes' *The Pastime of Pleasure*, Dame Astronomy says that hers is the last of the seven sciences :

> Vnto man it is also ryght profytable
> Shewynge the course aboue of the heuen
> Ryght merueylous for ony man to neuen
> Who knewe astronomy at euery maner season
> Myght set in order euery thynge by reason
> Also the other .vi. scyences lyberall
> By astronomy pryncypally were founde.

And again,

> the phylosophres proue
> That the planettes and sterres instrumentes be
> To natures werkynge in euery degre. (85)

A belief in the stars was quite logical to the Elizabethans. They saw the effect of the moon and sun; why, they argued, could not the other planets have similar effects? Vincentius gives a good illustration of their reasoning :

> Ffor we see openly that the mone taketh lyght whan we see her all full; ffor the man hath thenne neyther membre ne vayne but that it is ful, whan it is in the cours, of humours and suche thinges... And the see also floweth and ebbeth in his cours euery moneth;... In lyke wyse is it seen of the sonne that, after the wynter, whan he begynneth to mounte, he causeth the fruyt to be brought forth of therthe, and apparailleth the trees wyth leues, and alle verdure to come agayne; and the byrdes begynne agayn their songe for the swetenes of the new tyme... Syth that thise two starres haue suche vertues, and cause suche thynges to be

(84) Vincentius, *The Mirrour of the World*, trans. and ed. by Caxton, EETS, extra series, vol. 110, pp. 41, 128.

(85) Stephen Hawes, *The Pastime of Pleasure*, EETS, original series, vol. 173, ll. 2684-90, 2882-4. Editions in 1509, 1517, 1554, 1555.

don, the other whiche ben pourtrayed on the heuen were not made to serue of nought. But to eueriche is ordeyned his vertue and his right after his nature, wherfore they make dyuersytees in thynges that ben on therthe, and the moeuynges of tyme;... (86)

Or as AGRIPPA puts it,

It is manifest that all things inferiour are subject to the superiour,... so in the Heaven are things Terrestiall, but as in their cause, and in a Celestiall manner.

Thus we say that certain things are solary and certain others lunary according to whether the sun or moon makes a strong impression of its virtue;

So we know that Solary things respect the heart, & head, by reason that *Leo* is the house of the Sun, and *Aries* the exaltation of the Sun : so things under *Mars* are good for the head, and testicles, by reason of *Aries*, and *Scorpio*. (87)

Since man, along with other forms of earthly life, is inferior to the stars, it follows that the stars affect him. A well-known passage in *Hamlet* makes this clear :

> So, oft it chances in particular men,
> That for some vicious mole of nature in them,
> As, in their birth,—wherein they are not guilty,—
> Since nature cannot chose his origin,—
> By the o'er growth of some complexion,
> Oft breaking down the places and forts of reason,
> Or by some habit that too much o'er-leavens
> The form of plausive manners, that these men,—
> Carrying, I say, the stamp of one defect,
> Being nature's livery, or fortune's star,—
> Their virtues else—be they as pure as grace,
> As infinite as man may undergo—
> Shall in the general censure take corruption
> From that particular fault :...
>
> I. iv. 23-36.

Indeed, the familiar belief in inherent likes and dislikes falls back upon the stars for a logical explanation. BURTON says that the physicians believe it due to temperament, while astrologers ascribe it to trine and sextile aspects, or to the opposition of the several ascendants, or lords of their genitures. Since temperaments are imputed to the stars, the doctors were forced

(86) *Op. cit.*, pp. 145-6.

(87) HENRY CORNELIUS AGRIPPA, *Three Books of Occult Philosophy*, London, 1651, p. 48. This is a rather singular statement when we recall that another of AGRIPPA's works *(Of the Vanitie and Vncertaintie of Artes and Sciences)* was quoted previously as presenting arguments against astrology.

XUM

to agree with the astrologers (88). And MICHAEL DRAYTON declares that the cause of 'Ethiopian blackness and curled hair' has long been known to have risen from the singular operations of the heavens. Similarly, he continues, every country has peculiarities which are clearly due to celestial influence (89).

The way in which the stars made their influences felt in man was through the elements or humors of the body. The humors, in their turn, influenced the body in sickness and in health, and inclined the mind to this or that action (90). Perhaps a quotation from *The Four Elements* will make this conception more clear:

> But yet the elementis and other bodyes all
> Beneth take thyr effectys and operacyons
> Of the bodyes in the region ethereall
> By thyr influens and constellacyons
> They cause here corrupcyons and generacyons
> For yf the movynges above sholde onys cease
> Beneth sholde be nother increse nor decrease.
> ll. 169-175.

As GREENE tells us, however, it takes an astrologer to read what the stars foretell:

> Euery one that gazeth at the stars is not fit to discourse of Astrologie, neyther can fishermen tell the Physicall reasons of the motions of the Sea. (91)

A further belief of the Elizabethan, is that astrology offered much to him. This science taught him to know his friends and enemies; it prepared him for the future; it answered his every question. To the business man, it was especially a commonplace. Modern stock market operators, I understand, are a rather superstitious lot, and often consult an astrologer or fortune teller before undertaking a business venture; they are therefore not unlike the Elizabethan business men who called

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(88) BURTON, *op. cit.*, vol. III, p. 23.

(89) MICHAEL DRAYTON, 'Polyolbion,' *Works*, ed. RICHARD HOOPER, London, 1876, vol. I, pp. 26-27.

(90) JOHN SWAN, *Speculum Mundi*, Cambridge, 1635, p. 349. Cf. RUTH L. ANDERSON, *Elizabethan Psychology and Shakespeare's Plays*, Iowa City, 1927, pp. 54, 60.

(91) 'Euphues His Censure to Philautus,' *Works*, ed. GROSART, vol. VI, p. 204.

upon astrology to assist them in speculation (92). As VINCENTIUS expresses it,

> Certaynly who that knewe well Astronomye, ther is nothyng in the world of whiche he coude enquyre by reson but he shold haue knowleche therof. And many thynges shold he doo that sholde seme myracles to the peple whiche that knewe nothynge of the science. (93)

Later the science of astrology was made into a philosophy much in the same way that alchemy had earlier been transformed. VALENTINE WEIGEL has a book, *Astrology Theologized* (1649) (94), which takes up the subject from this point of view. Astrology, he says, is Philosophy itself; or it is the whole light of nature from whence arises the universal natural wisdom, or a 'solid, sincere, and exquisite knowledge of natural things.' This light of nature is twofold: external and internal; external in the macrocosm, and internal in the microcosm. Astrology, in other words, he asserts, is the very knowledge of good and evil. This science, he continues,

> flourishing in man, unless it be ruled and governed by Theology, that is Divine Wisdom, as the handmaid by her mistress, is vicious. And by her specious appearance, and concupiscible jocundity, man seduceth himself and, as it were by eating of the forbidden tree, or by whoring with the creatures, he maketh his soul the Babylonian Harlot sitting upon the Beast, having seven heads and ten horns, and being sweetly deceived of himself, obtains eternal death to himself.

WEIGEL later explains,

> The exercise of the Sabbath, or Theologization of Astrology, is, to die to thyself and the whole creature; to offer thyself wholly to God, with all things which are within and without. Hither belong all the Scriptures, and all the books speaking of the mortification of Man. (95)

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(92) Cf. RICHARD EHRENBERG, *Capital and Finance in the Age of the Renaissance* (rev. *LTLS*, April 26, 1928, p. 304); and HARDIN CRAIG, 'A Contribution to the Theory of the English Renaissance,' *Philological Quarterly*, VII (1928), pp. 322-3.

(93) VINCENTIUS, *op. cit.*, p. 160.

(94) VALENTINE WEIGELIUS, *Astrology Theologized. Wherein is set forth what Astrology, and the light of nature is... As Also That the Outward Man, how eminent in all Naturall and Politicall Sciences, is to bee denied, and to die in us; and that the Inward Man, by the Light of Grace, through profession and practice of a holy life is to be acknowledged and live in us; Which is the onely means to keep the true Sabbath in inward holinesse, and free from outward pollution*, London, 1649. Reprinted, London, 1886, by GEORGE REDWAY 'with a Prefatory Essay on the True Method of Interpreting Holy Scripture by ANNE BONUS KINGSFORD.'

(95) *Ibid.*, pp. 49-50, 91.

XUM

Although most of those Elizabethans who accept the tenets of astral divination do so without any qualifications, there are two authors of this period who make an attempt to modify it and to distinguish between valid and invalid astrology. These writers try to work out an Aristotelian mean between the position of the opponents of astrology and those who feel that there are no objections to the practice of the science. WILLIAM COVELL, in the *Polimanteia* (1595), explains his attitude thus :

> Some & of great learning would whollie make it frustrate, and exclude it from the liberall Arts, as teaching vs prestigious & false surmises vnder trueths colour. Some are so foolish, that they giue vnto it the force of gouerning the whole world :... (96)

Those who attack it, he continues, do so either because they feel it is uncertain, or because, under a show of religion, they say Jeremiah speaks against it (97). COVELL, however, intends to choose a middle path. He feels, in general, that it is ridiculous to cast horoscopes for cities and countries. He maintains that comets, eclipses, and the great conjunctions of the ' hye Planets ' foretell the future with accuracy in regard to nations and great bodies of people (98). As for other predictions, he accepts them with a great deal of reservation, setting forth that they are not so accurate.

FRANCIS BACON insists upon much the same attitude, but is much more specific in his beliefs. There are four ways only, he declares, by which this science can be approached. First by future experience, secondly by past experiments, thirdly by traditions, and lastly by physical reasons. Some of these, he states, have been neglected. But he would rather purify astrology than discard it altogether. The things BACON rejects are as follows : it is an idle invention, he protests, that each planet should reign in turn for an hour, and yet this conceit was the origin of the division of the week; the doctrine of horoscopes and the division of houses is an idle superstition; finally, a belief in the influence of the hour of birth and the hour of inquiry

(96) WILLIAM COVELL, *Polimanteia, or The meanes lawfull and vnlawfull, to iudge of the fall of a Common-Wealth, against the friuilous and foolish coniectures of this age*, London, 1595, sig. G2r-G2v.

(97) *Ibid.*, sig. G2v-G4v.

(98) *Ibid.*, sig. H1v-H2r, I1r.

is false. BACON receives the following beliefs as trustworthy elements of the science : that the effects of greater revolutions (but not of smaller, such as horoscopes and houses) are acceptable; that the operations of the heavens affect only the more tender bodies, such as humors, air, spirit, etc.; that the operations of the heavens extend rather to masses than to individuals, though it affects those individuals which are more susceptible than most men; that similarly, the heavenly bodies shed their influence not on small periods of time or within narrow limits, but upon the large spaces; and finally, that the stars incline rather than compel. In general, then, BACON accepts that first part of PTOLEMY's astrology which deals with general events rather than particular or individual ones. Into this ' sane astrology,' however, he receives practically all those things which appear in any outline of the subject, such as : aspects of the planets; approaches to and regressions from the perpendicular; accelerations, retardations, retrogressions, and progressions of the planets; the nature of the stars in general; and the particular nature of each of the planets (99).

ARGUMENTS

We recall that the chief opponent of astrology in SHAKESPEARE's day was JOHN CHAMBER. Two years after his book was published it was answered in full by CHRISTOPHER HEYDON in his *Defence of Iudiciall Astrologie* (1603). HEYDON replies to CHAMBER chapter by chapter. Before taking up the actual rejoinders, perhaps we should look at some general considerations advanced by HEYDON. First, we learn, God created the stars and foreordained their ministry, which He still sustains. God's purpose in this was to establish some means or instrument by which He might govern the inferior and elementary worlds. For proof of this, HEYDON offers an argument which is singularly modern in its implication : God must have some means of transmitting his will to man,

> For that cannot be truely said to be naturall, which is effected immediately

(99) FRANCIS BACON, *De Augmentis Scientiarum*, book III, *Works*, ed. SPEDDING, ELLIS, and HEATH, 7 vols., London, 1887-92, vol. IV, pp. 349-354.

by the powerfull and outstretched arme of God, without the intercourse of naturall causes, foreordained to that ende. (100)

HEYDON declares further, that it is wholly logical to believe that the stars influence men. If a bar of iron be forged in such a position that the ends lie due north and south, and remain in that position until cold, it will always turn to these points of heaven,

by reason of the impression, which at that time it receiued, as the needle, which is touched with the loadstone.

If the influence of the heavens be evident in things devoid of sense, why should it seem so unreasonable, asks HEYDON, that the delicate and tender body of the infant should have these natural properties imprinted at birth by the power of the planets, and that these properties should increase more and more as the child grows to maturity? (101) HEYDON's chief protest is that CHAMBER can propose no new considerations; that all his objections to astrology are taken from SEXTUS EMPIRICUS, PICUS MIRANDOLA, PERERIUS, SEXTUS AB HEMINGA, and others; and that these considerations were already answered by previous writers in defense of the science (102). HEYDON further remarks that astrology has not

much conuersed at any time with the meane, and vulgar sorte, but (to retayne her originall dignitie, her pedegree beeinge deduced from heauen) hath beene euer most familiar with great personages, princes, kings, and Emperours. (103)

It will now be well to examine some of the testimony and evidence offered to combat the objections of the opponents of astrology. It may be recalled that a strong argument advanced by the divines was that the Bible clearly disapproved of a belief in astral predictions. The defenders, however, could quote the Bible too. ROBERT RECORDE, for example, maintains that the testimony of CHRIST regarding His second coming legitimatizes this science, for He said that at such a time strange effects would

(100) CHRISTOPHER HEYDON, *A Defence of Iudiciall Astrologie, In Answer to a Treatise lately published by M. Iohn Chamber*, London, 1603. 'To the learned and vnpartiall Reader.'

(101) P. 164.

(102) This statement is found on nearly every page, but see especially the title-page and the preface to the reader.

(103) 'To the reader.'

be seen in the sun, moon, and stars (104). Similarly, THOMAS SWADLIN (D.D.) feels that the star at CHRIST's birth proves the willingness of God to make use of the stars to foretell events (105). And MOSES, says JOHN SWAN, testifying that God created the stars for signs, also shows that their meaning may be understood, otherwise they would not be signs to us (106). HEYDON maintains that the biblical quotations used by CHAMBER to combat astrology are in no way opposed to the science. CHAMBER has quoted a passage in which the Jews were reproved for following the heathens in their practices; HEYDON shows that this matter dealt with the worship of the stars and not with their use in predictions, and quotes AQUINAS for support. When CHAMBER quotes *Deuteronomy* 18 : 10, HEYDON asserts that the word *gnonen* used in this place means 'soothsayer' or 'witch.' HEYDON affirms further, that PICUS MIRANDOLA has mis-translated *Job* 38 : 33, and that CHAMBER has followed him. CHAMBER has argued that if the stars had any power, they got it from God; but that God never gave them the power, and therefore they had none; for if they had received any authority from God, He would not have forbidden their use. HEYDON, granting for the sake of argument that God did forbid their use, insists that CHAMBER's objection does not follow, because God gave power to the tree of life and yet prohibited the eating of its fruit; similarly God warned the Jews against eating certain meats. To what end, asked CHAMBER, did God forbid the tree of knowledge if He permitted the stars of knowledge to remain? HEYDON replies with another question asking why, then, didn't God prohibit all the other arts as well as astrology (107).

From the argument by biblical quotation, HEYDON moves on to the historical problem. Although it is true, he says, that some of the Church Fathers did oppose astrology, they did this believing that they must reject all rites and ceremonies of the heathens. Besides, HEYDON continues, all the Fathers did not

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(104) ROBERT RECORDE, *The Castle of Knowledge*, London, 1556, p. vii of preface.

(105) THOMAS SWADLIN, *Divinity No Enemy to Astrology: Intended to have been delivered in a Sermon to the Students in that Art, but prevented by the Sickness of the Author*, London, 1653; cf. 'To the Reader,' and pp. 1-3.

(106) JOHN SWAN, *Speculum Mundi*, London, 1635, pp. 346-7.

(107) HEYDON, *op. cit.*, pp. 26, 41-42, 47, 49, 119, 121, 206.

XUM

write against the science : DYONISIUS THE AREOPAGITE, for example, was a great astrologer who avouched the motions of the stars to cause limit, number, order, etc.; THOMAS AQUINAS, too, affirmed a belief that the stars had direct power over our bodies, but only an indirect power over the faculties of the soul. HEYDON also gives a list of well-known churchmen who upheld the science : such notable divines as EPISCOPUS VIENENSIS, PETRUS DE ALIACO, Cardinal CUSANUS, LEOPOLDUS, PAULUS DE MIDDELBURGO, LUCAS GAURICUS, and APOLLINARIS; such papists as PAULUS MONACHUS, VINCENTIUS, FRANCISCUS JUNCTINUS, MICHAEL A PETRA SANCTA, FRANCISCUS TOLETUS, and MARTINUS DELRIUS; and such protestants as MELANCTHON, PETER MARTYR, BULLINGER, MARLORAT, GARCOEUS, BEZA, BRENTIUS, *et al.* (108).

The discussion concerning the stars as causes was important, as we recall, because of the serious infringement upon the doctrine of free will. All the astrologers whom I have encountered, agree with their opponents that the stars are not causes of evil, nor do they enforce their influences; they merely incline inferior beings towards certain actions. ROBERT BURTON indicates this when he asserts,

> If thou shalt ask me what I think, I must answer... they do incline, but not compel :... they rule us but God rules them... So that, I hope, I may justly conclude... that the heaven is God's instrument, by mediation of which he governs and disposeth these elementary bodies; or a great book, whose letters are the stars,... wherein are written many strange things for such as can read, or an excellent harp, made by an eminent workman, on which he that can play will make most admirable music. (109)

Not only are the stars not causes, maintains SWAN, but had man not fallen, their inclinations in him would have been unnoticed, and their power in occasioning not felt. The evil, he continues, proceeds from the nature of man, who lost his purity and strength of will, in yielding to that which was forbidden; it comes not from the stars, but from the individual. The astrologers do not say, he concludes, that the stars are the causes of sin; our inclinations may arise from the heavens, but our will is the principal cause; it originally had the power to withstand all influence and even now ought to refrain from all inordinate

(108) HEYDON, *op. cit.*, pp. 56, 73f., 77-8, 81, 103-4.
(109) BURTON, *op. cit.*, vol. I, p. 235 ff.; cf. vol. III, pp. 279-280.

inclinations. SWAN uses the example of NERO who said that he was not compelled by the stars to engage in his monstrous sins, but in yielding to his lusts he willingly entertained those rages which the devil more and more instigated, and thus became even worse than the nature of the stars had originally made him (110). JAMES FERRAND adds that even the pagans in their practices did not deny the freedom of the will (111).

This feeling about inclinations is expressed very well by GREENE when, in *Greenes Mourning Garment*, Philador's country friend speaks as follows :

> But now *Philador*, enter into consideration of thy hard happe, and see into the cause of thy froward Fortunes : What? shall I attribute it to my natiuity, and say the Planets did calculate as much at my birth? no, there is no necessity in their influences, the starres determine, but God disposeth, thus :... (112)

Likewise, in *All's Well*, Helena says,

> Our remedies oft in our selves do lie,
> Which we ascribe to heaven : the fated sky
> Gives us free scope; only doth backward pull
> Our slow designs when we ourselves are dull.
> I. i. 202-5.

Since the stars do have an inclining influence, says Warwick, it behooves us to work with them and not against them :

> Your grace hath still been famed for virtuous;
> And now may seem as wise as virtuous,
> By spying and avoiding fortune's malice,
> For few men rightly temper with the stars;...
> 3 *Henry VI*, IV. vi. 26-9.

CHAMBER has listed four reasons why astrologers should not be heeded even when they foretell truly. HEYDON answers each of these objections as follows. Men who practice this science, said CHAMBER, are in league with the devil; HEYDON replies that since it is impossible for the devil to tell the truth, astrologers (who always speak with verity) can have nothing to do with him. Again, proposed CHAMBER, perhaps the astrologers' pre-

(110) SWAN, *op. cit.*, pp. 344-345.

(111) JAMES FERRAND, *Erotomania*, Oxford, 1640, pp. 54, 153-63. Cf. IOANNIS AB INDAGINE, *Briefe introductiones*, London, 1558, 'To the Reader'; HEYDON, *op. cit.*, 'To the Reader,' and pp. 19, 20-21, 30, 101.

(112) ROBERT GREENE, *Works*, ed. GROSART, London, 15 vols., 1881-83, vol. IX, p. 189.

XUM

dictions proceed from a secret disposition of God, and these wizards then predict with His help although they may not realize it; this is mere supposition, answers HEYDON, and if astrology were so odious that God prohibited it by law (as CHAMBER maintained) God would have nothing to do with it; on the other hand, if God did use astrologers for this purpose, then they should be reverenced. In the third place, stated CHAMBER, the practitioners of this science deliver their edicts in riddles which compare with those of the Sphinx; the astrologer should be commended then, remarks HEYDON, if his dexterity of wit can help him to frame his speech so that the event will always agree with his words. Lastly, said CHAMBER, astrologers are able often to foretell accurately because of the ' doltish dulnesse ' of those who resort to them and who ' suffer themselues willingly to be abused '; but why, asks HEYDON,

> doth he call their credulitie doltish, or dull, that beleeue the trueth which neuer faileth (as he hath here before put the case?) (113)

The point that astrologers were in league with the devil, is answered by other writers, as well. Indeed, the only actual proof which could be offered by those against astrology to support their contention, was the activities of quacks. Legitimate astrologers abhorred any connection with black magic and the like. About the middle of the sixteenth century, it is recorded, one astrologer, JOHN MAN, accused the inn-keeper HUGH DRAPER of being a ' conjurer or sorcerer ' and with directing his arts ' against S^{r} William S^{t} Lowe and my ladie.' (114) JOHN SWAN, furthermore, states that astrologers must be very careful not to permit any questionable practices to be joined with real astrology :

> Neither ought the observing of these signes to be mixed with characticall practices, diabolicall or superstitious divinations, making of images under such or such a constellation, dangerous elections of times, either to procure good or bring down ill from heaven, as they did who blasphemously maintained, that men are long-lived and their souls go to heaven when Saturn is in Leo : or they, who have not quaked to affirm, that when the Moon is joyned with Jupiter in the head of the Dragon, whatsoever a man then asketh at the hands of God, he shall receive. (115)

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(113) HEYDON, *op. cit.*, pp. 390-396; quotation from p. 396.

(114) G. L. KITTREDGE, *Witchcraft in Old and New England*, Cambridge, 1929, p. 258; cf. Heydon, *op. cit.*, p. 6.

(115) SWAN, *op. cit.*, p. 352; cf. p. 351.

SWAN also warns those engaged in making astral predictions to exercise care lest more be attributed to the heavens than to God, and castigates those believers in the science who make no journey or engage in no enterprise without consulting the heavens.

Perhaps it will be recalled that the opponents of astrology questioned the validity of using the time of birth for reading horoscopes. CHAMBER, for example, attacked astrologers for casting the horoscopes of SCIPIO AFRICANUS, MANLIUS, etc., because in these cases there had been no actual birth, the men being taken by Caesarean section; but he has misunderstood the word ' birth,' says HEYDON, which does not mean the time of travail but the time when the infant first comes to light. Again, CHAMBER asked if the astrologers could have cast the nativities of Adam and Eve. Of course not ! replies HEYDON, because astrology does not deal with supernatural creation. It must be impossible, maintained CHAMBER, to cast the horoscopes of some children because they are born in the daytime when the stars cannot be seen; CHAMBER is merely in ignorance of astrological instruments, insists HEYDON, who mentions TYCHO BRAHE's perfect minute-watch, the ephemerides, and other equipment. CHAMBER remarked that with people being born all over the world some must be born at the same moment; how was it, he asked, that they had not the same horoscope ? HEYDON's reply is, they were not born in the same latitude. Finally, CHAMBER asked if all those perishing on a shipwrecked vessel had been born under the same signs; to which HEYDON answers with a quotation from PTOLEMY's *Tetrabiblos*, ' The vniuersall causes are of more force and efficacie then particular causes.' (116)

The matter of twins was the basis for another convincing argument offered by the opponents of this science. CHAMBER had proposed this consideration, but HEYDON answers that even PICUS MIRANDOLA (from whom CHAMBER got his idea) knew this was no problem, for there is enough time between the complete births of twins to insure different horoscopes. As for CHAMBER's question concerning the countess of Holland and her 365 children, HEYDON replies that this was a miraculous birth, and therefore

(116) HEYDON, *op. cit.*, pp. 130f., 132, 141-143, 150, 535. Paraphrases in respective order with page numbers.

not in the realm of astrology. HEYDON further testifies that separate horoscopes for twins are not necessitated by a diversity of conceptions, but by the varying moments of birth. (117)

One of CHAMBER's arguments was that astrology did not take into consideration all the stars of heaven, and therefore could not be accurate. To this objection, HEYDON replies that the known and visible stars must be more powerful than the invisible ones, and that there are few stars of the first magnitude; furthermore, when CHAMBER states that there are 71,209,600 stars, it is pure speculation, believes HEYDON, and can in no way be proved. (118) It is true too, of course, that HEYDON had the Ptolemaic system of astronomy to support him, for the seven planets all had separate spheres while the remaining stars were confined to one sphere.

Again, CHAMBER argued that since astrology is sometimes false, it must be entirely discarded. HEYDON remarks that this objection would serve against all the arts; should we condemn divinity, he asks, because of the false doctrines of some divines? Or should we dispense with physic because doctors have been known to fail? Similarly, maintains HEYDON, the astrologer must not be censured if certain charlatans have misused the science; such an attack would be even more applicable to the doctor, since nothing is so full of quacks as the medical profession. (119) On the other hand, we see that astrology and medicine work hand in hand. Indeed, ask BURTON and HEYDON, what would the physician do without astrology? (120)

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(117) HEYDON, *op. cit.*, pp. 166, 236-237, 258. The story of the Countess of Holland is in part as follows : a poor woman having one child in her arms and another by the hand, asked the Countess for alms. Learning that the children were twins, the Countess remarked that it was impossible that this young woman could be virtuous. Whereupon the woman prayed that as a sign of her honesty, the Countess have as many children at one birth as there were days in the year. At her next travail (on good Friday, 1276), therefore, the Countess had this remarkable birth;... (HEYDON, p. 258).

(118) HEYDON, *op. cit.*, pp. 113, 377, 501-502.

(119) HEYDON, *op. cit.*, pp. 190-191, 550.

(120) BURTON, *op. cit.*, vol. I, pp. 196, 236; HEYDON, pp. 178-9.

Part Three

SHAKESPEARE

What was Shakespeare's attitude toward the science of astral predictions? It is impossible to say, I believe. If one says that Shakespeare is Edmund giving vent to his familiar diatribe against a belief in comets and eclipses, (121) surely he must also be Gloucester apprehensive over the same events, or Kent who intimates that all rulers are such because of planetary force :

> There is division,
> Although as yet the face of it be cover'd
> With mutual cunning, 'twixt Albany and Cornwall;
> Who have—as who have not, that their great stars
> Thron'd and set high?—servants, who seem no less,
> Which are to France the spies and speculations
> Intelligent of our state;...
>
> *Lear*, III. i. 19-25.

Again, if Shakespeare is Cassius urging Brutus to join the conspirators, saying,

> The fault, dear Brutus, is not in our stars,
> But in ourselves, that we are underlings, ...
>
> *Julius Caesar*, I. ii. 140-1.

he must also be Aumerle expressing an exactly opposite sentiment to Bolingbroke :

> Shall I so much dishonour my fair stars,
> On equal terms to give him chastisement?
>
> *Richard II*, IV. i. 21-22.

or Caesar who, regretting the death of Antony, remarks that it is lamentable

> that our stars
> Unreconciliable should divide
> Our equalness to this,
>
> *Antony and Cleopatra*, V. i. 46-48.

or King Henry who relinquishes his crown with these words :

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(121) Indeed, Professor Hardin Craig believes Shakespeare felt that Edmund's speech was the expression of the atheist and sceptic actually denying his religion ('The Ethics of King Lear,' *Philological Quarterly*, IV (1925), p. 104.)

XUM

> And that the people of this blessed land
> May not be punish'd with my thwarting stars.
> Warwick, although my head still wear the crown,
> I here resign my government to thee,...
> 3 *Henry VI*, IV. vi. 21-24.

This is not, however, the opinion of many who have discussed SHAKESPEARE and astrology. In general, those who believe in astrology today, feel that SHAKESPEARE accepted the science as valid. Authors of this opinion are represented by writers in the *Mercury* (an American magazine of the occult sciences, published by the Societas Rosicruciana in America), by members of the American Academy of Astrologians, and by WILLIAM WILSON in his *Shakespeare and Astrology, from a Student's Point of View* (Boston, The Occult Publishing Co., 1903). WILSON feels that SHAKESPEARE not only expressed the popular interest in, and understanding of astrological matters, but also

> seemed to have found time, at a time when study must have been hampered by the absence of astronomic material, to devote a very considerable portion of his attention to the gaining of knowledge on the subject.

He further believes that SHAKESPEARE himself was a 'Taurus man,' and that in the scene between Edmund and Edgar,

> it is the author himself who is 'sectary astronomical' and concerned with the development of a character under certain well known astrological conditions. (122)

Those, on the other hand, who feel that astrology is but a manifestation of the superstition inherent in mankind, are convinced that SHAKESPEARE would have none of it. FREDERICK SCHARK, for example, asks the question, and answers it in one word :

> War auch Shakespeare in diesem Sternenglauben seiner Zeit befangen? Nein ! (123)

Professor D. FRASER-HARRIS takes a similar attitude. He concludes his brief article by saying that SHAKESPEARE

> was very well acquainted with the astrological lore of his time, but as for himself in his heart of hearts he did not believe one word of it. (124)

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(122) WILSON, *op. cit.*, pp. 2-4.

(123) FREDERICK SCHARK, 'Shakespeare und die Astrologie,' *Hamburger Fremdenblatt*, Seite III, Nr. 202a (July 24, 1926).

(124) D. FRASER-HARRIS, 'Shakespeare and the Influence of the Stars,' *Discovery*, vol. VIII (1927), pp. 365-366.

Professor FRASER-HARRIS' chief point is Edmund's familiar passage, already mentioned, beginning,

> This is the excellent foppery of the world, that, when we are sick in fortune, —often the surfeits of our own behaviour,—we make guilty of our disasters the sun, the moon, and the stars, as if we were villains on necessity,... and adulterers by an enforc'd obedience of planetary influences, and all that we are evil in, by a divine thrusting on.

As we have seen, however, this is Edmund speaking and not SHAKESPEARE. For that matter, what does Professor FRASER-HARRIS make of the twenty-sixth sonnet?

> Lord of my love, to whom in vassalage
> Thy merit hath my duty strongly knit,
> To thee I send this written ambassage,
> To witness duty, not to show my wit:
> Duty so great, which wit so poor as mine
> May make seem bare, in wanting words to show it,
> But that I hope some good conceit of thine
> In thy soul's thought, all naked, will bestow it;
> Till whatsoever star that guides my moving,
> Points on me graciously with fair tatter'd aspect,
> And puts apparel on my tatter'd loving,
> To show me worthy of thy sweet respect:
> Then may I dare to boast how I do love thee;
> Till then not show my head where thou mayst prove me.

Or of the twenty-fifth?

> Let those who are in favour with their stars
> Of public honour and proud titles boast,
> Whilst I, whom fortune of such triumph bars,
> Unlook'd for joy in that I honour most.

Professor KITTREDGE in the conclusion to his well-known lecture, *Shakespeare*, gives the only answer to SHAKESPEARE's beliefs in general which we can hope for, namely, that we do not know, we cannot know, 'Nor would the knowledge either way profit us if we could obtain it.' (125) Our chief interest lies in SHAKESPEARE's use of astrology, rather than in his consideration of it as a valid or invalid science, for it is the former

(125) In this connection, note H. R. D. ANDERS' conservative opinion in his *Shakespeare's Books* (Berlin, 1904), 'Did SHAKESPEARE believe in starry influence? We hope not. But when we see an enlightened man of science, like BACON, unable to free himself completely from astrological notions, we may suppose that the great dramatist would have given a reserved answer to any enquirer desirous of knowing his opinion on this point.' (P. 239.)

XUM

which indicates his astrological knowledge as well as the general prevalence of interest in the subject. This knowledge of SHAKESPEARE's is surely attested by the remarkable number of passages in which an understanding of astrology plays a part. In *Titus Andronicus*, Aaron makes the following statement to Chiron and Demetrius :

> And now, young lords, was 't not a happy star
> Led us to Rome, strangers, and more than so,
> Captives, to be advanced to this height?
> IV. ii. 32-34.

Prospero, too, tells us,

> and by my prescience
> I find my zenith doth depend upon
> A most auspicious star, whose influence
> If I now court not, but omit, my fortunes
> Will ever after droop.
> *Tempest*, I. ii. 180-184.

In *Measure for Measure*, the Duke says to Claudio,

> A breath thou art,
> Servile to all the skyey influences,
> That dost this habitation, where thou keep'st
> Hourly afflict : ...
> III. i. 8-11.

The first scene of *All's Well* contains Helena's pronouncement upon the subject, to Parolles,

> That we, the poorer born,
> Whose baser stars do shut us up in wishes,
> Might with effects of them follow our friends,...
> I. i. 196-198.

And in reading the spurious letter addressed to him, Malvolio finds,

> In my stars I am above thee.
> *Twelfth Night*, II. v. 156.

After reading the letter, he states,

> Jove and my stars be praised.
> II. v. 187.

Most of the remaining passages are of such a general nature that it would be futile to continue quoting them; they will be found in the notes. (126) Suffice to say that Shakespeare's knowledge

(126) The following references to astrological passages in SHAKESPEARE have not been quoted : *Sonnets*, 14, 116; *Lear*, II. i. 38-40, IV. iii. 32-33; *Richard III*, III. vii. 171-172, IV. iv. 215, IV. iv. 402-5; *Coriolanus*, II. ii. 107-8; *Pericles*, I. iv.

was quite in accord with the astrological doctrines of the day, that he made use of this astrological knowledge in nearly every play he wrote, and that, since he was a playwright writing for the commercial theater, his employment of this science attests the familiarity of even the groundlings with the simpler tenets of the subject.

That astrology enjoyed its vogue during the days of SHAKESPEARE and found popular expression in almanacs and prognostications, we have ample proof. These latter certainly influenced public opinion, which in turn fostered the use of astrology in the literature and drama of the times. We have seen that so great was its popularity that scientists and scholars were in sympathy with it; that the church partly condoned it; and that the court accepted it with such avidity that it became a fad for the courtiers. Not only in England were manifestations of this pseudo-science current, but in continental countries as well. Astrology had had a following for thousands of years, and this following was no whit diminished in the days of SHAKESPEARE; the sixteenth and seventeenth centuries were a golden age for astrology just as they were for English literature. (127)

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107-8, II. i. 1, V. iii. 9-10; *Twelfth Night*, I. iv. 34-35, I. v. 188-9, II. i. 2-3; *Hamlet*, I. i. 162, I. ii. 112-4; *Winters Tale*, I. ii. 200-2, I. ii. 424-31, III. ii. 96-9, IV. iv. 77-8; 2 *Henry VI*, III. i. 206, IV. iv. 15-18, IV. i. 33-37; 1 *Henry VI*, IV. v. 6; *Henry VIII*, III. ii. 44-5; *All's Well*, I. iii. 235-7, II. i. 50-3; *Much Ado*, II. i. 301-2, V. ii. 36-7; *Titus Andronicus*, II. iv. 14-5; *King John*, III. i. 123-7, V. vii. 74-5; *Taming of the Shrew*, IV. v. 38-40; *Othello*, V. ii. 275; *Comedy of Errors*, I. ii. 41; *Cymbeline*, III. ii. 27-8, IV. ii. 3093-13, V. iv. 105-6; *Romeo and Juliet*, V. i. 24; *Antony and Cleopatra*, III. xiii. 144-7; *Timon of Athens*, IV. iii. 108; *Love's Labors Lost*, III. i. 72, V. ii. 395; *Two Gentlemen of Verona*, II. vii. 74; *Tempest*, II. i. 183; *Troilus and Cressida*, III. ii. 184, I. iii. 85 ff., II. ii. 46, II. iii. 206; *Winters Tale*, I. ii. 1, IV. iii. 24, I. ii. 425; *Lear*, V. iii. 19, I. ii. 137 ff.; *Hamlet*, I. i. 118; *Richard III*, II. ii. 69; 2 *Henry IV*, II. iv. 286; 1 *Henry VI*, I. i. 2; *Titus Andronicus*, II. iii. 30-1, IV. iii. 64-72; *Twelfth Night*, I. iii. 146 ff.; 1 *Henry IV*, I. ii. 15 ff., V. i. 18-21; *All's Well*, I. i. 210, I. iii. 91; 2 *Henry IV*, II. iv. 286-7; *Henry VIII*, IV. i. 54-55.

(127) I should like to thank the officials of the Henry E. Huntington Library for permitting me to use their remarkable collection; also Mr. THORDARSON of Chicago for letting me use his private collection which is replete with books on the Elizabethan sciences. Professor E. P. KUHL has read this paper in manuscript and his assistance of every kind appears throughout.

On Translation : Māyā, Deva, Tapas

Considered from a literary point of view, and still more with reference to their original value as *sādhana*, means to realisation, existing translations of Vedic texts may be described as amounting to little more than " cribs," of real use only as tools and in the hands of students who can and will take pains to consult the original texts. This is tantamount to saying that the Sacred Books of the East are even today inaccessible to those, and these the vast majority, who cannot read or even refer to the original texts. If, as many think, the only possible rapprochement of the West and East must be effected intellectually, herein lies the primary obstacle to a mutual understanding.

Mistranslation is not to be attributed to a lack of assiduity, nor to an inadequate mastery of Oriental languages on the part of scholars, but much more to their inadequate use of English. It would be an excess of consideration to deny that mistranslation has been in part the consequence of an unconscious religious bias in the minds, or rather hearts, of scholars, who beside having no facility of reference to first principles, are often subconsciously reluctant to allow that some other and non-Christian doctrine may possibly have meant the same thing that an accepted Christian doctrine may have meant to themselves, or if not to them individually, at least in European tradition. On the other hand, supposing a total absence of any religious bias in any modern scholar, his purely scientific outlook and special education will almost inevitably preclude in him a knowledge of Christian metaphysics, theology, and mystical literature where only is to be found the English terminology required for adequate translation. Such terms as unground, unknowing, abyss, procession, Spiritus, spiration, essence, nature, substance, hypostasis, regard, magic, angel, consonantia, comprehensor, are entirely unknown to him in their technical significance. Oriental translators, having acquired their

vocabulary and point of view mainly from the published works of European scholars, are similarly limited.

In illustration of what has been said I offer *suggestions raisonnées* as to the rendering of three well known Sanskrit words, viz. Māyā, Deva, and Tapas, proposing that they should be rendered consistently by " Magic," " Angel," and "Intension," or retained in their original forms untranslated.

Māyā

Māyā is one of the names of Prakṛti, the formative power or agency of manifestation in Iśvara, the Self-determined Self (Ātman), in which Self Puruṣa and Prakṛti subsist as conjoined principles. (1) In other words, in the arrangement of the Self, Puruṣa is " that of which," Ākāśa (2) " that wherein," Māyā " that whereby " there can be manifestation, actuality *(satya)*, " life."

This manifestation, which we miscall " nature " (3) and which is the phenomenal World *(jagat, loka)*, exists only *in act*, never pausing to *be*. Māyā-vāda doctrine does not assert that the World is Māyā, nor that the World does not become (4), but merely that it becomes in a certain way, viz. having Māyā as its ground *(pradhāna)* or means of becoming. Śūnya-vāda

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(1) The Sāṁkhya asserts an eternal distinction of Puruṣa and Prakṛti, and this distinction requires no proof so long as the standpoint of logic, implied in the term Sāṁkhya Darṣaṇa, " Enumeration Point of View," is adhered to. The Vedânta is not in opposition to the Sāṁkhya as such, but assumes another Point of View (Darṣaṇa), viz. the Advāita (Non-Dual), in which the ever-existent Duality is envisaged, not as annihilated, but as subsumed in an Eternal Unity. So then, while Sāṁkhya by definition deals with Existence (Satya), Vedânta points out that the two " Persons " known in relation are of one Essence, viz. Ātman.

(2) Elemental space, the Playground of the Spirit *(prâṇârāma)*, finite by definition, though endless : " located " in the " lotus of the heart ".

(3) " Nature " might have been a legitimate rendering of " Māyā " were it not for our habitual error in identifying Mother Nature *(natura naturans)* with her children, the World, *ens naturata*.

(4) How far removed is the Vedânta from a " denial of the world " can be seen in Śaṇkarâcārya's own words with reference to the Ātman as Bliss : " On the vast canvas of the Self, the Self itself paints the picture of the manifold worlds, and the Supreme Self itself takes great delight in the sight thereof " (*Svâtmani-rūpaṇa*, 95).

XUM

doctrine, which cannot be divorced from that of Tathatā, "Suchness" and that of Yathābhūta, "As is," does not assert that the World does not become : what it asserts is that the World is at once "Void" (5) and "Suchness." That is, the World is unreal to the extent that we think of it as a Duality of separate self-subsistent *(svâvasthita)* principles, but real in its Suchness, "As is"; which is only another way of expressing the Vedântic view. The only further doctrine conceivable (6) might be called Ātma-vāda, with reference to the doctrine of Ātman as *mis*understood in early Buddhism, where it is supposed that the Vedas posit Ātman (Self) as Subject in relation to Object; it need only be pointed out that in fact the Ātman is "not so" *(neti, neti)*. So then what the Vedânta denies is that knower and known, etc. (although separately *conceivable* from our point of view) "are" separate and self-subsistent *(svâvasthita, svayambhū)* entities; what it asserts is that knower and known, etc., "are" conjoint aspects of the Self (Ātman), which Self is manifested in the Unity of Pure Act as the Becoming of the World (7). In other words, the World *is* the Self (Ātman) or Suchness (Tathatā); through our empirical understanding of the World is Error (Avidyā).

"By my Māyā I (Self) become (the World)" (8). As neither agent nor agency is synonymous with act (becoming), so Māyā is not the World *(jagat, loka)* of existences *(bhūtāni)*. Māyā may be called Moha, delusion or illusion, that *by which*

(5) Śūnya, not elemental Space (Ākāśa), the *sine qua non* of existence, but Absolute Void, an "aspect" of non-existence.

How far removed is the Mahāyāna point of view from a denial of the world (in the sense that we deny the "horns of a hare" or the "son of a barren woman" appears in the magnificent equation *yas saṁsāras tat nirvāṇam*, "the circus of the world is in itself enfranchisement".

(6) We cannot take into serious account the "common sense" view that things "are what they seem" : sufficiently refuted by other "common sense" observation "all is not gold that glitters," not to mention the familiar example of the rope mistaken for the snake.

(7) The Vedānta more often expresses this directly, without reference to the conjoined principles (Puruṣa and Prakṛti, Prajāpati and Vāc, etc., (Christian "Person" and "Nature", "Father" and "Word") by an affirmation of the "non-duality" *(advāita)* of the Self (Ātman), and the formula "That art thou".

(8) References in this paragraph are to *Bhagavad Gītā*, IV, 6 and VII, 13-15, and 27. Cf. *Śvetâśvatara Upaniṣad*, I, 10 and IV, 8-10.

the World is deluded *(mohita)*; but those deluded *(muḍha)* beings of fallen nature *(asura-bhāva)* whose pure Intelligence *(prajñā)* has been torn away by Māyā are not themselves illusions, for however remote may be their Enfranchisement *(māyā-nivṛtti, Śvetâśvatara Upaniṣad*, I, 10) may be, even of these it can still be said " That art thou." By what net *(jāla, kalila)* then is the World deluded " that it knows not Me (Self) "? By the properties (the three *guṇas*, viz. energy, mobility, inertia) variously perceived in beings, so that they are mutually distinguished; and by the " pairs " *(dvandvāu)*, notions whereby the world is seen as thesis and antithesis. The delusion of the ego consists in its erroneous perception of the world, itself included, as a plurality of self-subsistent units, and its consequent attachment to or aversion from such units as such. This "delusion", in its personal aspect *abhimāna*, egoity, " I-ness ", " original sin," is shared by God himself, in so far as he is in the world as Puruṣa, Person, Eternal Man; but it would be an aspect of the same delusion to conceive of God (him-Self) objectively as having any potentiality whatever not completely actualised in the totality of simultaneous becoming, delusion that is, to conceive of " Him " as other than the world *sub specie aeternitatis*. To deny a self-subsistence to the world is not a negation of anything whatever, in any other sense than that in which we deny the actaulity of the horns of a hare, or deny that omnipotence could make that which has been or may be in time, (and therefore is beyond time), not to have been or to become in time or not to be the farther shore of time.

Needless to remark that what is called action, life, change, and euphemistically " progress," really represents nothing more than a sequence of the reactions of the ego to the qualities and pairs of opposites, and that all such unaware and functional reaction represents, from the Vedic point of view, not Life, but merely " living ". For example, the acquisition of information is not " Life," but only a reaction of the knower to the known (fact). More specifically, knowledge as Realisation *is* Life, the Life of the Self, neither in the knower not the known, but in itself as *adaequatio* (Skr. *tadākāratā*) *rei et intellectus*, immediate and eternal act : art is in the same way Life, neither in the seer nor the seen, the artist nor the work, but in itself as *consonantia*

(Skr. *sādṛśya*) *diversorum;* devotion and desire *(bhakti, prema, kāma)* not in the lover or beloved, but in the meeting of lover and beloved in the undimensioned cave of the heart, " Verily not for love of any angel, husband, wife, being or possession whatsoever dear, but for the love of Self," *Bṛhadāraṇyaka Upaniṣad*, II, 4, 5, and " He who approaches (9) any angel other (than the Self), thinking ' He is one and I another,' knoweth not *(na sa veda)*," *ibid.* L, 4, 10. That only is " Life " from the Vedic point of view which is thus experienced immediately at the core of " our " consciousness, in the transcendental Self; and is outwardly manifested in a pure facility or spontaneity (Skr. *sahaja*, Chinese *shên*, Muḥammadan *islām*, Christian resignation (10) without anxiety or motive *(a-sakta)*, as action that is not action (11). The " Gospel " of the Veda, though the Veda speaks in terms of knowledge and not according to the *bhakti-vāda* (religion), is the doctrine that this enfranchisement, freedom and enlargement in the fullest sense of the words (12) is always and forever virtually realised and actually realisable : " The Kingdom of Heaven *is* within you," " *This day* shalt thou be with me in Paradise " (13).

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(9) *Upâsthe*, employed also with reference to carnal union, cf. *ibid.*, VI, 4, 1-3.

(10) Positively understood, *sannyāsa* as incentive *(Bhagavad Gītā*, III, 30). This is an antithesis of fatalism, cf. BOETHIUS " the further a thing is from the First Mind, the more it is involved in the chain of fate " (*De. Consol*, IV, cited by ST. THOMAS, *Sum. Th.*, I, Q. 116, A. 4). " —although the holy doctors avoided the use of this word (fate), on account of those who twisted its application to a certain force in the disposition of the stars " *ibid.* A. 2.

It may be remarked that the four terms bracketed in explanation of " facility " are not quite of one kind, *sahaja* and *shên* representing effect, and *islām* and Christian resignation cause. But cause and effect in immediate experience are the same.

(11) *Bhagavad Gītā*, IV, 17. ECKHART, I, 149, " The just seeks nothing in his work; only thralls and hirelings ask anything for work, or work for any why... have no ulterior purpose in thy work... enter thou into thine own ground and work; works wrought by thee there are all living."

(12) *Mukti, mokṣa, nir-vāṇa*, as *an-āvṛtti, a-sākta*, " enlargement," " freedom," in the fullest sense of the words.

(13) According to ST. THOMAS : in pure being (Self as subject) intellect and will tend not to anything external but remain in, and are, the subject or agent, nature being one with essence. A vital procession of intellect and will takes place respectively as (1) intelligible act (knowledge, art) and (2) actual love (Vidyāpati's " Each is both"), that is, in so far "as the object loved is in the lover... the object spoken of or understood is in the intelligent agent." Life " does

Māyā then is " nature " strictly and technically, not "Nature" as the world, which ought properly to be described as " natured," *prakṛti-ja* or *prākṛta* (14); Māyā being the means by which manifestation is effected. The Creator (Prajāpati, etc., or Īśvara *qua* Prajāpati-Vāc, Father and Word), as master of this means, is designated Māyā-vin; the world is *māyā-maya* "made of" or "in the mode of " *māyā*, "magical". . Further, the comparison is made of his creations, productions or manifestations with those of the mortal magician whose *indra-jāla* (" net of Indra ") is a bewildering *(moha-kalila)* or spell-binding *(vaṣī-karaṇa)* analogous to the very world as we perceive it sensibly. English " magic " and " magician " in this sense are exemplified in the " pleye " *(līlā)* and person of Merlin, as described in the fifteenth century English version of a *Roman de Merlin* no longer extant in full : " quod Merlin... I cowde here reyse a Castell, and I cowde make with-oute peple grete plente that it sholde assaile, and with-ynne also peple that it sholde defende, and yet I sholde do mo maistries, for I cowde go upon this water and not wet my feet, and also I cowde make a river where as neuer hadde be water," which he performed, making all these things to proceed from the forest (Brioke) and to be seen in a circle " in myddel of the launde," and when they had " long dured, " to return at the close of day to the forest, disappearing " sodaynly, that con ne wiste where thei were become " (15). As BÖHME says, " The Magician has power in

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not proceed from potentiality to act," but is all act. (*Sum. Th.* I, Q. 27, A. 2 and A. 4). Similarly ECKHART, almost in the words of the Upaniṣad, " God is in all things self-intent " (I, 380), " tireless in working as in loving, and it is all the same to him what he is loving. Which shows the love is God... The good man... formed in the image of God... loves for his own sake, that is to say he is loving for love's sake, working for work's sake, for the same reason that God is loving and working without ceasing : divine activity is his nature, his being, his life, and his felicity... the good man behaves the same as God not only in loving all he loves and doing all he does on account of God whom he loves therein and for whom he works, but in loving too (i.e. at the same time and by the same act) and working for himself, the lover " (II, 66-67), where " God " and " the good man " are the Self.

(14) Bhāva = (Māyā *Bhagavad Gītā*, VII, 13, 14) is " nature " universally : *sva-bhāva*, nature generically or individually, as when we speak of the " horse-nature " or " horsiness " whereby a horse is a horse, or of the specific nature by which a given horse is that horse and no other.

(15) *Merlin*, II, 309-311, Early English Text Soc., vol. 21, 1899. The accuracy and precision of the passage cited above will not be overlooked,

this Mystery *(Mysterium Magnum*, the Divine *emanation)* to act according to his will, and can do what he pleases," forasmuch as " each mysterium is the mirror and model of the other," though " he must be armed in that element wherein he would create" (16).

It is again BÖHME who explains the world as the creation of a Divine Magician using a Divine Magic : " Magic is the mother of eternity, of the being (existence) of all beings... the original state of Nature... a matrix without substance, but manifests itself in the substantial being... it has in it the *Fiat*... in Magic are all forms of Being of all beings. It is a mother in all three worlds, and makes each thing after the model of that thing's will. It is not the understanding, but it is a creatrix according to the understanding, and lends itself to good or to evil... Magic is the mother from which Nature comes, and the understanding is the mother coming from Nature... In sum, Magic is the activity in the Will-spirit " (17).

Magic is thus God's skill or art *whereby* He manifests or brings about the becoming of the world; and is in other beings by participation, or as " the mirror or model of the other." Nothing further is required in proof that Sanskrit " Māyā " should be translated as English " Magic."

Deva

Īśvara (saguṇa Brahman, Ātman) and personal names such as Śiva or Viṣṇu when applied to Īśvara are the only proper Sanskrit equivalents to " God " in the Christian sense; the *nirguṇa* Brahman being Godhead. From the fact that Īśvara is also Deva, Bhūta, Yakṣa, Asura, etc., though the chief in each of these classes (as is often denoted by the prefix Mahā, " Great," as in Mahādeva), and inasmuch as each of these generic designations can be applied with reference to an indefinite variety of states of being in the " Three Worlds ", has arisen the widespread notion of a Hindu

though it may well be that the later Arthurian authors no longer " understood " their material. Celtic mythology, including " Merlin " and the " Grail legend " (for which see my *Yakṣas*, II, 37 f.) represent a survival of ancient tradition as to Life, parallel to what of the same tradition is preserved in orthodox doctrine.

(16) BÖHME, *Sex Puncta Mystica*, VI, 2-5 (A.D. 1620), in EARLE's version. (*Six Theosophic Points*, and other writings, New York, 1920.)

(17) BÖHME, *Sex Puncta Mystica*, V.

polytheism; just as from the Muḥammadan point of view the Christian Trinity represents a polytheism, though this is an erroneous interpretation (18). But as a Christian may say, and ECKHART does, that God is " just Being," and must yet speak of other " beings " of all sorts without intending that God is merely *a* being amongst others perhaps inferior or equal to another, so both a unity and hierarchy are taken for granted in the Vedic terms Deva, etc. Even within Christianity there has been discussion as to the propriety of calling God an angel, the general conclusion being that this is rather a matter of convenience than of faith, the " Angel of Great Counsel " of Isaiah, IX, 6, Sept. Ver., presumably referring to God, cf. ECKHART's expression " premier angel ", and the " One Angel " of *Bṛhadār. Up.*, 1, 2, 7.

The usual and indiscriminate rendering of Deva as " God " or " god," while referable in part to *idées fixes* presuming pagan polytheism, has also an etymological sanction, and affords a good example of the kind of error that can arise from a careless dependence on a scientifically correct derivation, Deva corresponding in fact to Latin *deus*, English deity, divine, though warning might well have been taken from Zend *daeva* that Sanskrit Deva need not always denote precisely " God ".

Deva is literally " Shining One "; the proper rendering is " Angel," the higher Devas being principles or pure intelligences or " Aeons ", whose " shining " *(prabhā, prakāśa)*, represented in art as a nimbus or rays, is reflected in the possibilities of existence (Māyā, or Āpaḥ the " Waters ") as actuality, existence. Devas and Devatās are called the " limbs" or "members" *(aṅga)* of Brahman, or the "attributes" *(bhakti)* or "powers" *(vibhūti)* of the Ātman according to their hierarchy *(sthāna-vibhāga)*: just as the Christian Angels are the ministers, powers, and messengers of God, in their hierarchies and orders. The correspondence extends so far that just as in the Indian tradition

(18) One can very well understand how the Islāmic doctors could misinterpret the doctrine of the Trinity as polytheism, if we consider such statements as ST. THOMAS. "Wo do not say *the only God*, for Deity is common to several" (Sum. Theol., I, Q. 31, X. 2). What is even more remarkable, " ... holy men are called gods by participation, " ST. THOMAS, *Sum. Th.*, I, Q. 108, A. 5. Indic scholars might have taken warning here before they took for granted " polytheism " or invented " kathenotheism ".

we find the seats and vehicles *(āsana, vāhana)* and attributes and weapons *(āyudha puruṣa*, etc.) of the Devas, Īśvara included, themselves also spoken of and represented iconographically as Devas, so the Christian hierarchies include in the highest choir an order of " Thrones," and in the second one of " Powers "; the virtue of the Powers being at God's Will " to impose order on those subject to them," to " coerce the evil spirits," and so forth, just as the Āyudha Puruṣas of Indian Devas appear at their command, and are the means by which their will is carried out. Angels and Archangels are orders in the lowest choir, whose functions are most nearly connected with human life, they being sent as messengers to men, or acting as regional or individual guardians, for which there are abundant parallels in Indian tradition, even to the existence of individual guardians *(ārakkha devatā)*. Vedic and Christian tradition are also in agreement as to the angelic independence of local movement. And finally, while the number of the Devas is often said to be thirty three thousand, and that of the angels incalculable, the words of St. Thomas " nor is this said to signify that this is the precise number of angels " can be applied in both cases (19).

Further, when the Devas as individuals are called " undying " *(amara)* this refers to their perpetuity on a given plane-of-being *(loka)* not subject to any further change of state *(punar mṛtyu)*, " again death " (20) in the course of Time, though this does

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(19) Authorities for all the statements in the foregoing paragraph are : Yāska, *Nirukta*, VII, 5; *Bṛhaddevatā*, I, 70, 71, 73 74 and 98; *Bṛhadāraṇyaka Upaniṣad*, III, 9; *Tāittirīya Upaniṣad*, I, 5, *aṅgānyanya devatāḥ;* my *Yakṣas*, Pts. I and II; St. Thomas, *Summa Theologica*, I, Q. 107, A. 4, *ibid.*, Q. 108, A. 5-7, *ibid.*, Q. 112, A. 4, and *ibid.*, Q. 113, A. 1.

(20) Vedic tradition envisages the voyage *(yāna)* of the individual after death as a passing *on* from one plane of being to another, with the possibility of perpetuity on any given plane until the end of time, with a return to incarnation in another age, for those who have not achieved either a total or even partial gnosis. The later doctrine of incarnation in which the possibility of a return to a previous or even lower plane seems to represent the edifying tendencies of the religious extensions, perhaps incorporating popular non-Vedic elements, cf. my *Yakṣas*, I, p. 14, note 1. The idea of actual rebirth on any former plane in the case of a " special incarnation " *(avatāra)* is avoided, in the case of the Buddha, by the doctrine of *nirmāṇa-kāya*, which corresponds to the Docetic heresy in Christianity (the Son of Man = *nirmāṇakāya*, Christ in Glory = *sambhogakāya*, Christ as Logos = *dharma-kāya*).

The word *karma* ought not to be rendered " causality," but simply " works,"

not preclude the natural return of their being to Brahman at the end of Time *(kalpânta)* (21), a kind of death, indeed, but absolutely, *mors janua vitae* (22). The Devas are also called

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" action," " making," etc. In so far as we can think at all of cause and effect as separated in time, the word *apūrva*, " latency," " non-immediacy " represents the nearest equivalent of " causality "; the *pūrva-kara-kṛta-vāda*, " due to former action doctrine " asserting that antecedent action has determined present event. Cf. EDGERTON, *Mīmāṁsā Nyāya Prakāśa*, New Haven, 1920.

" Reincarnation " as interpreted by Buddhists (and now by Theosophists) is hardly a Vedic doctrine. Even the descent of the Pitṛs, "Fathers" (a collective term) is not a return of individuals as such to a former state of being, but in a far more general way the unforeseen *(adṛṣṭa)* working out of antecedent or " inherited " causes in present effect. Devayāna and Pitṛyāna are the ascent and descent on Jacob's ladder.

(21) Mahā-Pralaya, in Christian terms the " Last Judgement." Those " judged " and admitted to "heaven," that is absolute and non-contingent immortality, correspond to those in Vedic terms who have achieved a partial realization following the *pitṛ-yāna* or *deva-yāna :* the judged and " damned " to those whose bondage (*pāśa*, individuation, ignorance, sin) has been such as to preclude the possibility of even a partial and deferred enfranchisement *(krama-mukti)*, and must therefore await in an " everlasting " but not eternal latency, their mortal rebecoming in another Time *(kalpa)*, when naturally the possibility of achieving or not achieving a deferred or an immediate total realization will again present itself. " Damnation " in this sense, that is to say a self-condemnation to an endless (though not eternal) latency, a relative (though not absolute) annihilation, is adjudged to those who conceive the Ego as the Self, thinking that to act " for the sake of the Self " means nothing but to satisfy every desire of the Ego, by serving the body here and now; those who live by such an " Asura Upanisad " as this " shall perish," *Chāndogya Upaniṣad*, VIII, 8. In Christian terms, the " Fall " consisted in an assertion of the independence, self-subsistence, of the Ego (Satan's claim to " equality " with God). The same in nature, is described as an eating of the fruit of the Tree of the Knowledge of Good *and* Evil (which is the Tree of Life conceived in terms of the " pairs of opposites "). This Tree may be seen by the Self with great delight, as it grows in the Garden of Life *(prâṇārāma)* ; but the fruit thereof (" things as they are in themselves," not as " they are in God ") assimilated *(tadākṛtvā)* by the Ego, is deadly venom (*viṣa*, cf. root *viṣ* in other senses); eating of the fruit is a taking on of what is nothing in itself, so " Mortal Sin " against the Spirit, Death from the standpoint of Eternal Life. Only the Self can swallow such venom and yet Live : as Śiva does when by another image the *dvandva* is produced at the Churning of the Sea of Milk (" Waters," the possibilities of being), the marks of which are the blue-black stain on His throat as Nīlakaṇṭha, Viṣakaṇṭha, Viṣāgnipā, and His " addiction " to drugs. The apparent subjection of the Self to the tragedy *(arta)* of " life," that accepted pain, is the Passion of God and Everyman.

(22) Bodhisattvas are conceived of either as *ājānaja-devāḥ* (Tāitt. Up., II, 8) " natural " or " begotten angels "; or as having taken birth, and then as *karma-devāḥ* (ibid.) " angels will respect to works ", enduring after death as Saviours or Intercessors until the end of Time, or it may be forever in Time

undying not as individuals, but as to the station *(sthāna)* occupied, and this refers to their eternity as principles, as when we say that in another age some other individual than is the present Indra will occupy the throne of Indra. From the latter point of view, in the *Pañcavimśa Brāhmana*, VI, 9, 15 f., the Devas are spoken of as a first emanation *(prathamam asṛgram)*, an enduring utterance *(sthita vyāhṛtiḥ)*, and contrasted in this with individual existences *(mānuṣyāḥ*, "men," "mortals") whose existence is "day by day" *(svaḥ, svaḥ)*. In complete accord with this, it is asserted by ST. GREGORY and ST. AUGUSTINE, "*angelus nomen est officii, non naturae*"; and just as certain of the higher Devas are not involved at the end of time, so "the angelic orders... according to the difference of grace and nature... will ever remain ...(but) as to the execution of the angelic offices it will to a certain degree remain, and to a certain degree will cease"—at the Day of Judgement (ST. THOMAS, *Sum. Th.*, I. Q. 108, A. 7). And further, just as the deceased are in part to be spoken of as Devas (and this is one of the specific reasons why the rendering of Deva as "God" or "god" is improper) so "men can merit glory in such a degree as to be equal to the angels, in each of the angelic grades; and this implies that men are taken up into the orders of the angels" (ST. THOMAS, *ibid.*, A. 8).

It has now been sufficiently demonstrated by a detailed collation of corresponding notions as to the nature and functions of Devas and Angels, that the rendering of Deva as "God" or "god" (22a) (which last means little more nor less than "false god") is only legitimate when the highest Deva is expressly or implicity referred to, and that in all, or almost all other cases the word "Angel"

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and Time again, notwithstanding that total despiration *(nirvāṇa)* is fully within their grasp. Bodhisatvas of the latter type correspond to the Vedic Apāntaratamas and others, the possibility of whose reincarnation *(avataraṇa)* despite their attainment of Perfect Gnosis, is discussed by Śaṅkarâcārya, Comment. on Vedânta Sûtras, III, 3, 30, 31. The following passage very especially applicable to the case of a Bodhisattva: "In the case of beings of this kind, who owing to particular deeds have been appointed to particular offices, the effect of the works which have risen to the office does not pass away before those offices are completely accomplished." Any such descent involves a Passion, of which Siddhârtha's Abhiniṣkramaṇa affords a specific instance.

(22a) Both "God" and "god" should be excluded from translations of Pali texts, where Brahmā is not the supreme deity, but only the highest of the Angels, and the Buddha is not yet "deified".

should be employed. The same will hold good for Yakṣa in most contexts, but Yakṣas, though in one hierarchy, are of very diverse orders, some being fairies and elves rather than angels; it is generally best to retain the original word. When Deva and Asura occur together, the same generic designation must be applied to both (just as Michael and Satan are equally " Angels "), and if a distinction has to be made Asura must be translated " Dark Angel" or better "Daimon". It remains to point out that *Viśve Devatāḥ*, the " Several Angels ", generally (e.g. *Bṛhad Devatā*, I, 69 f.) means the three Persons of the Trinity *(tridhā)*. But as expressed by ECKHART (II, 153) "the angel hosts are countless," but "to one who knows distinction apart from time and number an hundred would be the same as one."

Tapas

The practise of *tapas* is primarily an intellectual process by which the creative powers of any being are strengthened and focussed; with an empirical equivalent in the practise of various austerities by Yogīs or others. Examples are the *tapas* practised by the Deity (God as Creator with respect to a given temporal cycle) preparatory to the creation of a universe; and the *pañcâgni tapas* of Umā practised with a view to regaining Śiva's specific partiality. *Tapas* is a passion voluntarily undertaken, and with a known end in view. It might well be described as a raising of the spiritual potential to the sparking point : Böhme's "flash", "flagrat", "enkindling", or Hebrew *ẓimẓum*. The usual rendering of *tapas* is " penance "; but notwithstanding that the notions of pain, effort, sweating, and fusion are symbolically present, " penance " is altogether improper, inasmuch as there is no idea of expiation with reference to the past, but only of a tension towards a future end. Śaṅkarâcārya (23)explains *tapas* as "*kṛcchra*, etc.," a noun from root *kṛṣ*. to draw together, obtain, master, and implying exertion, retention, etc. Now there are English words *intension*, defined (Webster) as " strain, energetic exercise (as of the mind), increase of power or energy "; *intense*, " showing its characteristic attribute in a high degree, wrought up to high activity "; and

(23) Commentary on *Tāittirīya Upaniṣad*, I, 9.

intensify (intrans.), " to become intense or more intense ; to act with increasing power or energy." From which it is sufficiently apparent that *tapas* should be rendered generally by " intension," and the verb, *tap*, generally by " intensify."

In conclusion : I conceive the proper end of " Comparative Religion," regarded as a discipline, to be the demonstration of the identity of the common metaphysical tradition underlying all religious extensions : which when established (which can only be done intellectually, and not with any immediate view to edification, intellect being defined as " the habit of first principles ") will permit religions in the plural to exist side by side as variations necessitated by the infinity of the theme and the variety of human character, the thing being always in the knower according to the mode of the knower. What Europe has understood by " religious tolerance " is a merely negative conception, reached by way of scepticism and political convenience. The basic principle of tolerance is positive; in the words of YĀSKA, " We see actually that because of the greatness of God, the one principle of life is praised in various ways"; RUYSBROECK, " Because of his incomprehensible nobility and sublimity, which we cannot rightly name nor wholly express, we give Him all these names " (24). Cf. JALĀLU'D DĪN RŪMĪ, "I have bestowed on everyone a particular mode of worship. I have given everyone a peculiar form of expression"; IBN AL-'ARABĪ, "God, the omnipresent and omnipotent, is not limited by any one creed, for He says (*Qur'ān*, II, 109) 'Wheresoever ye turn, there is the face of Allāh'... If one understood Junayd's saying 'The water takes its colour from the vessel containing it', he would not interfere with other men's beliefs, but would perceive God in every form of belief", and "I follow the religion of Love, whichever way his camels take"; Ḥāfiz "Where the turbaned anchorite chanteth Allāh day and night, church bells ring the call to prayer and the cross of Christ is there "; *Bhagavad Gītā*, IV, 11, " the path men take from every side is Mine". Indeed, as AŚOKA, " the Darling of the Angels," saw, " he who does reverence to his own sect while

(24) YĀSKA, *Nirukta*, VII, 5 cf. *Brhad Devatā*, 1, 70 and 98. RUYSBROECK, *Adornment of the Spiritual Marriage*, Ch. XXV.

disparaging the sects of others, with intent to enhance the splendor of his own, in reality by such conduct inflicts the severest injury on his own " (25). Those who accept, understand, and live by the Vedic tradition cannot admit that it represents either a polytheism (25a), pantheism (25b,) or a denial of existence, and offer valid proofs in refutation of any terminology of this kind, such as scholars generally employ. Nor can an initial rapprochement of Europe and Asia be conceived on any other than an intellectual basis as above defined, not forgetting that from the Oriental and Scholastic (that is verily European) points of view, " art " is a part of intellect.

So then the importance cannot be exaggerated of rendering " the holy heathen books " not merely with grammatical accuracy, but as to specific terms in their context, with a precise awareness of their real meaning, and by means of the exact or nearest possible equivalents in English. This is of such immediate necessity that we ought not to hesitate to make over all existing translations that are not from this point of view entirely competent, remembering that translations are not made as ends in themselves, but to be read, marked, learnt, and inwardly digested. True that this would involve a drastic revision of almost all existing versions of Vedic texts, and much more besides; but the task is one the present generation ought not to shirk. The scholar is in duty bound by the terms of his vocation.

APPENDIX

Appended is a sample version of *Bṛhadāraṇyaka Upaniṣad*, I, 2, 1 and 2, where Genesis is traced as from the *nirguṇa* Brahman

(25) AŚOKA, Rock Edict XII.

(25a) *Bṛhad Devatā*, I, 70 and 98 : " Because of their Great-Self-hood (*mahātmya*) a diversity of names is given to the Angels... (but) the Divinity (*devatva*) of each Angel is from-their-being-of-one-sphere (*sālokyatvāt*) and of one-and-the-same-birth (*ekajātatvāt*) and because-of-the-immanence (*vyāptimatvāt*) of the Fiery-Energy (*tejas*) in them, though they are seen to be individually worshipped (*stutaḥ*)".

Whether the designation "polytheistic" can be properly applied to any known religion may be doubted. On the Sumero-Accadian pantheon from this point of view see LANGDON, *Semitic mythology*, p. 89.

(25b) Cf. *Rg Veda*, X, 90, 3, "One fourth of Him is all existences, three fourths immortal"; *Bhagavad Gītā*, VII, 12, "not I in them, but they in Me".

not yet determined as One; *ibid.*, I, 4, 17, where Genesis is traced from the *saguṇa* Brahman, already Self-determined One; and *Pañcaviṁśa Brāhmaṇa*, VIII, 8, 1, where the creation is described almost in the terms of the Hebrew Genesis. Where Sanskrit words are rendered by more than one English word, this is indicated by hyphenation. Capitals denote the universal, lower case the general and particular. Sanskrit words are bracketed and some notes added in justification of my renderings; but the translation is designed to be intelligible to a reader altogether without Sanskrit. I claim that these are at once literal and literary versions, and so transparent as to be easily understood by anyone familiar with any other aspect of the same tradition, that is in the first place to any English reader familiar with the Old Testament.

Bṛhadāraṇyaka Upaniṣad, I, 2, b and 2.

In the beginning no thing whatsoever was here. This-all *(idam)* was veiled by Death *(mṛtyu)*, by Privation *(aśanāyā)*; for Privation is Death (26). That *(tad)* took on *(akaruta)* intellect *(manas)*, " Let me be Selfed " *(ātmanvī syām)* (27). He (*saḥ*, the Self) gave out light *(arcan acarat)*. Of Him, as He shone *(arcataḥ)* were the Waters *(āpaḥ)* born *(jāyanta)* (28). Verily whilst I shone, there was Delight " *(kam)*, He said *(iti)* (29), This is indeed the Sheen *(arkatva)* of Shining *(arka)*. Verily, there is affirmation for him who knoweth thus the sheen of shining.

The Waters, verily, were a (counter-)shining. What was the foam of the Waters, that solidified, that became-the-one *(vyaśavat)* Earth *(pṛthivī)*. Thereon He strove *(aśrāmayat)*. Thereafter *(tasyânta)* the Fiery-Energy *(tejas)* and Tincture *(rasa)* of His striving *(śrāntā)* and intension *(tāpta)* broke-forth-as *(niravartat)* Fire *(agni)* (30).

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(26) " Lifelessness is... lack of an intrinsic form." ST. THOMAS, *Sum. Th.*, II, Q. 6, A. 2.

(27) Cf. *Tāittirīya Upaniṣad*, II, 7, *svayam akurut*.

(28) I.e., Light made visible the Possibilities of Being.

(29) Cf. *Bṛhadāraṇyaka Upaniṣad*, VI, 4, 6. *Iti* is here German *also*.

(30) Conception of the " interior Word," His knowledge of Himself.

(*Ibid.*, 3, He (Self) becomes a threefold Principle of Life; and is described as elemental-space-body *(ākāśa-śarīra, Tāittirīya Upaniṣad*, I, 6) the wherein all the possibilities of being are to be realised. *Ibid.*, 4, as also in I, 4, 17 translated below, the manifested Self by entering into union with his own Nature, whose birth as Mother is the answer to his consciousness as Father, begets on Her the Year, that is Time, as All Things).

Bṛhadāraṇyaka Upaniṣad, I, 4, 17.

In the beginning This-All *(etad)* was just Self *(ātman)*, One *(eka)*. He *(saḥ)* willed *(akāmayat)*: " Let-there-be *(syād*, " fiat ") of Me *(me)* a wifely-birth *(jāyā)* that *(atha)* I may beget *(prajāyeya)*. Let there be of Me Goods *(vitta)*, that I may work Works *(karma kurvīya)* (31). So great indeed is Will *(kāma)* (32). Nor if one would could anyone get *(na... vindate)* more than that. Thereby-it-hangs *(tasmād)* that even here-and-now *(adya)* when one is single *(ekākī)* he wills " Let there be of me a wife *(jāyā)*, that I may beget. Let there be of me goods *(vitta)*, that I may work works *(karma kurvīya)*. And

(31) Often rendered " sacrificial works "; but though this is by no means excluded from the context, the sense is here wider. The Vedic view is that all works done with knowledge are ritual or sacrifice *(yajña)*, cf. the application of this doctrine to carnal union, *Bṛhadāraṇyaka Upaniṣad*, VIII, 4, 3.

(32) *Kāma*, as Will, is one of the essential names of Self; therefore susceptible of dual arrangement as Will (Kāmadeva) and Desire (Rati), and a threefold arrangement as Will *(kāma)*, Delight *(ānanda)*, and Desire *(tṛṣṇa)*. The word *kāma* has in fact all these implications. Much confusion has been caused by the Buddhist conception of Kāmadeva only as a contracted *(tāmasika)* aspect of Desire. It was no doubt inevitable that in a system where the doctrine of Self was not understood, Will could be thought of only as a Thirsting *(taṇha)*; it was in fact only with great difficulty that Buddhism came to conceive of a " True " Will (*satya kāma, Chāndogya Upaniṣad*, VIII, 3, 1; *dharmâviruddha... kāma, Bhagavad Gītā*, VII, 11) not motivated by a need, though this had been present in the notions " Kāma " *saṃkalpa*, and *vaśa* from Vedic times. And from the specifically Buddhist point of view, the identification of Kāmadeva with Death (Māra) and Satan (Pāpman) was correct. But Eros, as *primum mobile*, is a mighty Power, and cannot be so easily disposed of. In the same way Buddhism conceived of Death only in its *tāmasika* aspect as evil. Whereas (as we saw above, *Bṛhadār. Up.*, I, 2, 1) Death *(Mṛtyu)* and Indigence *(Aśanāyā)* are not less than Life and Abundance essential names of the Supreme Identity, whose nature-essence is the simultaneous pulse of Manifestation and Non-Manifestation *(vyakta, avyakta)*, Existence and Non-existence *(sat, asat)*.

XUM

in so far as he is indigent *(ekāika)* of these, verily he thinks " I am not whole *(kṛtsna)* ".

Now His *(tasya)* Wholeness *(kṛtsnatā)* (33) is thus : His intellect *(manas)* is Himself, His Word *(vāc)* is His wifely-birth *(jāyā)* ; His Spirit is His Begotten *(prajā)* ; His Eye *(cakṣu)* is his Rational *(mānasa)* Goods *(vitta)*, for verily by Sight *(cakṣuṣā)* He comes-into-possession-thereof *(tad-vindate)* ; His Ear *(śrotra)* is His Angelic *(dāiva)* Goods, for verily by hearing *(śrotrena)* He heareth that *(tacchṛnoti)* (34); Himself *(ātman)* indeed is His Works *(karma)* for it is by-means-of-Himself *(ātmanā)* that He works Works.

The sacrifice *(yajña)* is five-fold. The Offered-beast *(paśu)* is five-fold. The Person *(puruṣa)* is five-fold. This all, whatever there be, is five-fold. Who knoweth This, wins *(apnoti)* All (35).

Pañcaviṁśa Brāhmaṇa, VII, 8, 1.

Unto the Waters *(āpaḥ)* came their Season *(ṛta)* (36). The

(33) Cf. Gnostic " Pleroma ".

(34) Eye, as that whereby substantial form *(rūpa)* is sensed, and Ear as that whereby name *(nāma)* is heard, are symbols respectively of the sensible and intelligible worlds, particular and general : transcendental knowledge, requiring no organic symbol, has been mentioned above, " His intellect is Himself," where *manas* = *prajñā*.

(35) " Five-fold " refers to the five vital spirits *(prâṇa)* and (or) Five Elements *(tanmātrā)*. *Paśu* may be taken to mean " man " individually, cf. *ibid.*, I, 4, 10 : Puruṣa, Humanity, Universal Man, Adam. In Hume's versions of the above passages, careful as they are, the rendering of *arcan* as " praising," *kāma* as " desire," and *vāc* as " voice " are misleading. Cf. *Br. Up.* IV, 1, 2, *Chāndogya Upaniṣad*, VII, 2, 1 and *Kāuṣītaki Upaniṣad*, III, 5, where the meaning is in each case " Word," with *Br. Up.*, III, 2, 3, where *vāc* is really " voice," that is functional utterance, mere sound *(ruta)* : combining these sources, it is clear that Name *(nāma)* comes between *vāc* as " Word " and *vāc* as " voice," as proximate determinant *(parastāt prati-vidhānaka)* of the former, and " over-apprehender " *(ati-grāha)* of the latter.

(36) The Waters are all the possibilities of being, in themselves pure potentiality, no thing,this nothing being as it were at large in the elemental-space-body *(ākāśa-śarīra)* of the Self. " Where time has never entered in and no form was ever seen, at the centre, the summit, of the soul, there God is creating this whole world" (Eckhart, I, 164) : but more specifically, the possibilities of being with reference to a particular *loka* or *kalpa*. In any book of Genesis a chronological mode of expression is inevitable, but it must not be forgotten that all the possibilities of being are from eternity simultaneously potentialities and actualities, the Self-determined Self, the One, being Ever-Act and All-Act, as well as Inaction. The

Gale-of the Spirit *(Vāyu)* stirred *(ārcchat)* their Back *(pṛṣṭha)* (37) There-from became *(samabhavat)* a Fair-Thing *(vāma)* (38). Mitra-Varuṇa counter-saw-themselves *(paryyapaśyat)*; they said " A Fair-Thing verily has here come to be amongst the Angels " *(deveṣu)* (39). Hence the Fair-Angelic *(Vāmadevya)* chant.

ANANDA K. COOMARASWAMY.

Waters, Skr. Āpaḥ, feminine collective plural, are an aspect of Prakṛti, Vāc, Māyā, etc., that is, Potentiality as distinguished from Power, hence the propriety and poetry of *ṛtu*, implying " ripe unto conception," " full of promise."

(37) The Earth is often spoken of and represented as a lotus leaf floating on the " back " of the Waters, e.g. *Śatapatha Brāhmaṇa*, VII, 4, 1, 8 and X, 5, 2, 8; the " back " or " face " of the Waters being a given plane of being, *loka*. In a closely related figure the Earth is thought of as condensed foam, as in Br. Up., I, 2, 2, translated above. On this floating leaf or Earth the Creator lies *uttānapad* (RV., X, 72, 3), intensifying *(tapati)*, until in the fulness of time there springs up from his navel as generative centre the Tree of Life (see my *Yakṣas*, II, pp. 1-3) which is also the Tree of the Knowledge of Good *and* Evil *(dvandvāu)*. In place of a lotus leaf we find very usually that the Deity reclining on the Waters is supported by the Nāga Ananta (Eternity as Permiseive Principle of Time) as his couch *(śayana)*. In another way the nascent Creator is represented as a child (Kṛṣṇa) cradled on a banyan leaf, floating on the infinite Sea, as Vaṭa-patra-śayin.

(38) That is, the World Picture *(jagaccitra)*, cf. Śaṇkarâcārya, *Svâtmanirūpaṇa*, 95, cited above, Note 4; and ECKHART, " the words ' God saw was that it was good '... express a certain satisfaction taken by God in his works, as of an artist in his art," "finding his reflection most delightful".

(39) " The Angels " i. e. the Trinity of Fire, Supernal-Sun, and Spirit. The being of the natural or begotten Angels *(ājānaja devāḥ)* is, as we have already seen, eternal *in principio* and quâ essential names of the Self; they are conceived of as already present at the stirring of the Waters, as above, or as taking part in the primordial drama *(nṛtya)* or in Churning of the Waters, *samudra manthana*, at which time the *karma-devāḥ*, " angels by works ", are embodied.

Outline of a history of differential geometry (*)

I

1. — *The Time before Leibniz.*

It is difficult to talk of differential geometry before LEIBNIZ. There were many applications of infinitesimals to geometry before, but almost without exception they were quadratures and rectifications of curves, cubatures and quadratures of surfaces or solids, and studies of special curves, subjects we now exclude from differential geometry proper, except as occasional illustrations. Only a few topics have an immediate bearing of our subject.

Among them we have to mention the investigation of the nature of tangency found in EUCLID's " Elements " (last part of 4th century, B.C.), discussed only in the case of a circle. EUCLID explains, in Book III, as a " definition " that a straight line is tangent to a circle if it meets the circle and does not intersect it after being continued. Also in Proposition 16 of the same book a property of tangency is explained. The tangent to a circle, it is said here, will fall outside the circle and no other line will fall in the space between this straight line and the circumference. This property of the tangent was taken up again later and generalized by LAGRANGE, when he developed his theory of contact (*Théorie des fonctions analytiques*, Seconde partie I, 5). EUCLID himself tries to describe the nature of contact more in detail in the same proposition, in which he states that " the angle of the semicircle is larger than any rectilinear acute angle, the remaining angle smaller." This suggestion of extending the notion of

(*) This outline was given in a series of ten lectures at the Massachusetts Institute of Technology during fall and winter of 1931-32.

angle to so-called horned angles, though having been the subject of long discussions, has not been carried far in differential geometry. (1)

Similar ideas can be found in the works of ARCHIMEDES and APOLLONIUS. APOLLONIUS (3d century B.C.) makes full use of the normal to a plane curve in his theory of conic sections. He goes further; he finds that the normals to a conic section have an envelope, and he determines this envelope in the three cases of an ellipse, parabola and hyperbola. (2) He comes so closely to the conception of curvature that KEPLER, in a book on optics, could talk of the circle of curvature at a point of a parabola, as if it were well-known to all his readers. (3)

In the same treatise on conic sections (in book II) we find the asymptotes to a hyperbola. The technical name for these lines is also due to APOLLONIUS (*ἀσυμπτώτη*).

ARCHIMEDES (287-212 B.C.) occasionally discusses subject matter relevant to differential geometry, as in the beginning of his books on the sphere and the cylinder, where he defines the straight line as the shortest distance between two points in the plane. He states in this work the definition of curves " concave in the same direction " and arrives at the statement that if two plane curve segments with the same endpoints are concave in the same direction, the curve lying between the straight line connecting the two points and the other curve is shorter than this other curve. He establishes similar theorems for surfaces. This paper includes, for instance, the theorem that when a convex plane curve lies inside another convex plane curve, its circumference is the shorter. The curves also may be partly or entirely composed of line segments, or may partly coincide. (4)

The problem of isoperimetrical figures belongs also to antiquity, and is now included in that part of differential geometry which utilizes calculus of variations. POLYBIUS, historiograph of the Punic

(1) Comp. F. KLEIN, Elementarmathematik vom höheren Standpunkt aus. (Berlin, SPRINGER) 1925, p. 222 sequ. See E. KASNER, *Bulletin Amer. Math. Soc.* (2) 17 (1910-11) p 393.

(2) APOLLONIUS OF PERGA, ed. TH. HEATH (Cambridge, 1892), p. 160-179.

(3) J. KEPLER, " Paralipomena in Vitellionem, " Ch. III, Theor. XIX, Werke II, p. 175. (*Ostwald's Klass.* 198, p. 54).

(4) See e. g. ARCHIMEDES, French translation of VER EECKE, p. 4-6.

XUM

wars, remarks that most people measure the size of towns or camps by their perimeter, and that they can hardly believe that Sparta, with a circumference of 48 stadia, is twice as large as Megalopolis with a circumference of 50 stadia. (5) The mathematics of this problem seems to go back to the time before ARISTOTLE. A series of theorems is found in a paper by ZENODORUS (about 150 B.C.), who stated that the circle is larger than all plane figures of the same circumference, and the sphere larger than all solid figures of the same area. Exact proofs, as a matter of fact, date back only to the 19th century.

Then there is the problem of mapping the earth on a plane, a problem which offered itself to those geographers of Antiquity who recognized the earth as a sphere. The principal contribution is due to PTOLEMY (150 A.D.), though we may readily believe that his ideas were those of HIPPARCH, who lived three centuries earlier. In PTOLEMY's *Geography*, Chapter 24, we find what we now call the stereographic projection. He takes the equator as plane of mapping, and he not only explains the projection, but also shows its conformal character. He also modifies the projection by mapping the figure on a cone tangent to the sphere. This allows a good representation of that part of the earth known to PTOLEMY. The " map of the world according to PTOLEMY," reproduced in many textbooks, is drawn in this projection. (6)

We cannot deal here with the reasons for the slow progress of differential geometry in Antiquity, as it is only one aspect of the much more general problem why antiquity did not advance beyond ARCHIMEDES in the calculus of infinitesimals. We remark that it has to do only, in a general way, with the fact that the economic system on which the Mediterranean culture was based already began to decay in the last centuries of the Roman republic.

Many new methods of mapping a sphere on a plane were invented in the sixteenth century, when the great discoveries gra-

(5) POLYBIUS lived from 201-119 B.C. The place is from his Books IX, 21. Our information on isoperimetry is taken from W. SCHMIDT, " Geschichte der Isoperimetrie im Altertume," *Bibliotheca mathematica* (3)2 (1901), p. 5-8. See also M. CANTOR, Vorlesungen I, 3d ed., p. 357.

(6) Map projections also in PTOLEMY's " Planisphaerum " and " Analemma." The name " stereographic projection " is due to F. D'AIGUILLON (1566-1617), a Belgian Jesuit, who has Monge, central, and stereographic projection in his " Optics " (1613). (He calls the first two orthographic and scenographic).

dually widened the knowledge of the terrestrial sphere. In 1540, GEMMA FRISIUS, professor at Louvain, again used the stereographic projection. Of greater importance is the work of GERHARD KRÄMER, Latin MERCATOR (1512-1594), a Flemish cartographer who lived a good part of his life at Duisburg. He used many map projections, of which one carries his name, because he used it for the first time in the famous map of the world of 1569. This method, the only one invented by the great cartographer, projects meridians and parallels into straight lines. MERCATOR knew the properties of his map very well, for instance its conformity, and the meaning of the straight lines. He discriminates between " plaga " and " directio," the " plaga " being the shortest connection between two points on the earth, the " directio " the shortest distance on the map. This " directio," in the words of MERCATOR, is not straight, but " oblique curvatur." For large distance and high latitude there is considerable difference between " plaga " and " directio". (7)

There was a considerable literature on MERCATOR projection in the next decades, and connected with it we find a discussion of the " directio." NUNES (as early as 1544, in print 1573), STEVIN, SNELLIUS, WALLIS, LEIBNIZ contributed. The name " loxodrome " is due to SNELLIUS' *Typhys Batavus* (1624).

Earlier than FRISIUS and MERCATOR, J. WERNER suggested, after JOH. STABER, a projection (1514), which conserves areas. It was used in 1531 by O. FINAEUS for a map of the world, and in 1538 by MERCATOR. This map, with its curious heart-like shape, is seldom used. (8)

The many new investigations on curves and on infinitesimals connected with the names of KEPLER, DESCARTES, FERMAT, CAVALIERI and others are mostly of too special, or too general a nature to find discussion here. A point of inflexion was first discussed by DE SLUSE (1668) and FERMAT (1679). (9) But to the early history

(7) See H. v. AVERDUNK, GERHARD MERCATOR (1914), p. 128 sequ. The properties of the MERCATOR projection in the Legenda to the map of 1569. In v. AVERDUNK also discussion of the other literature.

(8) Annotationes JOANNIS VERNERIS, Nuremberg 1514; O. FINAEUS, De linearum, superficierum et corporum dimensionibus (1531). See H. v. AVERDUNK, *l. c.* (7)

(9) See M. CANTOR, Vorlesungen II (1892), p. 840; III, p. 194, see however G. ENESTRÖM, *Bibliotheca mathematica* 12 (1912-13), p. 156; 13 (1913-14), p. 168.

of differential geometry belongs certainly the *Horologium oscillatorium* of CHRISTIAEN HUYGENS (1629-1695), his book on pendulum clocks (1673) (10). The problem of measuring time in an exact way suggested here a new mathematical theory. One of the chapters of the book gives a complete theory of evolutes and involutes in the plane. HUYGENS wanted a pendulum so constructed that the period of vibration would be independent of the altitude. This is the problem of the tautochrone. The solution is that the mass of the pendulum moves, not on a circle, but on a cycloid. But the evolute of the cycloid is another cycloid. We can therefore get a tautochronic pendulum by forcing the thread of the pendulum to move along the circumference of two small parts of a cycloid with cusp at the point of suspension and cusp tangent in the direction of equilibrium. To find this form of the " cheeks " HUYGENS develops the general theory of evolutes and involutes (" evolutae " and " evolventes", as he calls them), in the plane and he gets an expression, in geometrical form, for the radius of curvature. Here we also find the theorems that the involute intersects orthogonally the tangents of the evolute and the relation between arc-length of involute and length of the tangent to the evolute.

2. — *The First Systematic Contributions*

When LEIBNIZ started his work, analytical geometry of the plane was well under way, as was the application of infinitesimals to quadratures. His main contributions to differential geometry can be found in papers of 1684, 1686 and 1692.

In the *Nova methodus pro maximis and minimis*, the first paper in which LEIBNIZ published his new method (*Acta Eruditorum* 168), we already find the interpretation of the equation $d^2y = 0$. It indicates a point of inflexion, a conception, as we saw, introduced by DESLUSE and FERMAT. In a paper of 1686 (11), we find the circle of osculation, but not the expression for its radius in analytical form. LEIBNIZ thought in his paper that the circle of osculation passes through four consecutive points of the curve, because

(10) German translation in *Ostwald's Klassiker*, 192.

(11) LEIBNIZ, Meditatio nova de natura anguli contactus et osculi. *Math. Schriften*, ed. GERHARDT II 3, p. 326-329.

it has two contacts with it. After a remark by JACOB BERNOULLI (1692, *Acta Eruditorum*) he readily recognised that only three consecutive points come into consideration. The word " osculation " is taken from this paper of 1686.

In 1692, LEIBNIZ published (12) his theory of envelopes of a family of plane curves $f(x, y, a) = 0$. It is necessary for this to eliminate between $f = 0$ and $\frac{\delta f}{\delta a} = 0$. This early result is the more remarkable, as only in recent times some essential advance is made on this statement. In another paper of 1692 (13) we find a discussion of evolutes and involutes, mainly a statement of HUYGENS' results, with the additional remark that the different involutes are " parallel," the first place where this word is used for plane curves.

To what extent differential calculus was applied to geometry in those early days of the new method can be estimated by the recently published lectures of JOHANN BERNOULLI at Basle in the winter of 1691-92. (14) There we find computation of tangents to plane curves, with cycloid, cissoid, quadratrix, as examples. Maxima and minima are found by taking $dy = 0$. The condition $ddy = 0$ leads to points of inflexion, as shown for the case of conchoid and versiera. Even polar coordinates in the plane are introduced. In the Integral calculus, written at the same time, the radius of curvature appears (14). L'HOSPITAL wrote his *Analyse des infiniments petits* (1696), the first published textbook on the calculus, under the influence of these lectures of BERNOULLI; L'HOSPITAL did not add much of interest to us.

With the entrance of the BERNOULLI brothers into the field a highly competitive race for new results begins. The principal figures become engaged in bitter quarrels, LEIBNIZ against NEWTON, JOHANN against JACOB BERNOULLI. The net result for science was a development of such rapidity that even modern times can

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(12) LEIBNIZ, De linea ex lineis numero infinitis ordinatim ductis inter se concurrentenbus formata easque omnes tangente. *Acta Eruditorum* 1692. LEIBNIZ *Math. Schriften*, ed. GERHARDT, II 1, p. 266-269.

(13) LEIBNIZ. Geneialia de natura linearum, anguiloque contactus et osculi. *Math. Schriften* 2e Abh. III, p. 331-337.

(14) Differential calculus : *Ostwald's Klassiker* 211, Integral Calculus (Opera III, p. 386) : *Ostwald's Klassiker* 194.

scarcely break the record. Before 1700 many new curves are discovered, many ordinary differential equations are solved, the first elliptic integral is introduced, and the calculus of variations is set up. In 1697 and 1698, the BERNOULLIS study geodesic lines on a surface; JOHANN discovers that osculating plane and tangent plane are perpendicular : " quod planum transiens per tria quaelibet puncta proxima lineae quaesitae debeat esse rectum ad planum tangens superficiem curvam in aliquo istorum punctorum." (15) The equation of the geodesic lines does not appear either in print or in private letters, though JOHANN claims that he has found it. (16) JACOB also outlines an inquiry into the so-called isoperimetrical problems. Both brothers investigate orthogonal and more general trajectories in the plane. The name " trajectory " occurs in a letter of JOHANN to LEIBNIZ of 1698. (17) An application of this theory was found in the theory of light in a medium of varying density, under HUYGENS' assumption that a ray of light intersects the wave front orthogonally. An application of JACOB lies in the finding of the orthogonal trajectories of logarithmic curves.

The problem was taken up again in 1716, when LEIBNIZ, in the priority quarrel, tried to induce NEWTON to show the power of his methods. He asked NEWTON (via CONTI) to find the orthogonal trajectory to a given set of curves, for instance, all hyperbolas of equal center and vertex. NEWTON answered, but only in a general way and his answer does not suggest the best method of attack. He seems to indicate that the finding of orthogonal trajectories depends on the determination of their center of curvatures as intersections of consecutive normals to the given curves; this suggests a differential equation of the second order instead of the first. (18)

This brings us to the question of the contributions of NEWTON to the application of analysis to geometry. Here we are unable to find much worth mentioning except his general method. If

(15) For the literature see M. CANTOR, Vorlesungen III (1908), p. 229, 232, 235. The quoted passage in a letter to LEIBNIZ of August 1698.

(16) In letters to LEIBNIZ, see G. ENESTRÖM, Sur la découverte de l'équation générale des lignes géodésiques, *Bibliotheca mathematica* 13 (1899), p. 19-24.

(17) JOH. BERNOULLI, Opera I, p. 266, see CANTOR III, p. 222, 233, 443-445.

(18) See CANTOR III, p. 444, 445.

he really wrote his *Theory of Fluxions*, published in 1736, as early as 1671, he was the first to find an analytical expression for the radius of curvature of a plane curve. But this is doubtful. (19)

This dearth of investigations on differential geometry, which continued in England long after NEWTON's death and even now has not disappeared, is the more remarkable as the method of fluxions was geometrical. NEWTON's reasoning was always geometrical, the algorithms belonging to LEIBNIZ. But even later, in MACLAURIN's *Theory of Fluxions* (1742), in which hardly any formulae are used, we do not get more differential geometry than the old theory of curvature for plane curves. The justifying claim was that the book established more exact foundations of the Newtonian way of reasoning.

We have already reported on certain publications in the early 18th century, but they are isolated and contain no new results. The same may be said of a series of papers by PIERRE VARIGNON (1654-1722) (20) on evolutes and related subjects. Of more importance is a paper by R. A. F. DE RÉAUMUR (1683-1757), which generalized evolutes by considering lines intersecting a plane curve under arbitrary angle. Then he obtains evolutes which he calls " imparfaites." (21) It was a youthful production of the later thermometrist and investigator of the social life of insects. But this is almost all we can find. After 1700 the interest in differential geometry declines sharply. The young instrument of analysis is used for other purposes. Geometrical problems remain almost untouched for several decades. But the fertile days of LEIBNIZ and the BERNOULLIS achieved a considerable result. We have nearly the whole scheme of elementary differential geometry of plane curves.

3. — *The Eighteenth Century*

For many years we have practically the work of two men, but they were great geniuses : CLAIRAUT and EULER.

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(19) *L. c.*, p. 171, 172.

(20) VARIGNON, *Mémoires prés. par div. sav.* 1700-1713.

(21) REAUMUR, Méthode générale pour déterminer le point d'intersection de deux lignes droites infiniment proches qui rencontrent une courbe. *Mém. prés. par div. sav.* 1709, p. 149-161.

XUM

ALEXIS CLAUDE CLAIRAUT (1713-1765), when still a boy of sixteen, wrote his *Recherches sur les courbes à double courbure* (1731), which brought him, at eighteen, into the Académie des Sciences. The book is mainly analytic geometry of space, a subject new in those days. Space curves enter as intersection of surfaces, not as independent entities. CLAIRAUT uses algebra, differential and integral calculus in a study of these curves. In differential calculus he considers tangents, subtangents and subnormals. Only those normal lines to space curves are considered that are normal to the surface on which the space curve lies, which implies the knowledge of the existence of the tangent plane to a surface. CLAIRAUT also finds the locus of the points of intersection of the tangents to the space curve with the plane of projection, and the same for the normals.

The integral calculus gives the possibility of rectification and cubature. Here we find at the same time the development of a curve on its projecting cylinder, " si l'on imagine que la surface cylindrique... s'étende le long du plan RAP et se développe pour ainsi dire."

CLAIRAUT's examples are algebraical curves, as the intersection of $y^2 = ax$ and $z^2 = by$, or $x^2 + y^2 = a^2$ and $y^2 + z^2 = a^2$; sometimes he considers a transcendent curve, as the cycloid.

In the last part of the book he asks for the curve on a surface, " décrite en faisant tourner dessus un compas dont une pointe est attachée à un point fixe C," but he does not think so much of geodesic circles as of the intersection of a simple algebraic surface (as the sphere) with a cone. Another set of problems is created by having a curve roll on another (congruent) curve in a plane perpendicular to the plane of this curve, which he specifies for parabola on parabola and circle on circle.

Of importance is the name of the book, through which " courbe à double courbure " became the recognized technical term. CLAIRAUT got the name from HENRI PITOT (1695-1771), in his time a famous hydraulical engineer, who used it in a paper of 1724 dealing with the helix. (22) Neither PITOT nor CLAIRAUT, however, expressed by their choice of the name any knowledge

(22) H. PITOT, Quadrature de la moitié d'une courbe des arcs, appellée la compagne de la cycloide. Histoire de l'Académie de Sciences, 1724, publ. 1726, p. 107-113.

of first and second curvature. " J'ai crû devoir appeller ces sortes de courbes, courbes à double courbure, parce qu'en les considérant de la façon qu'on vient de dire elles participent pour ainsi dire toujours de la courbure de deux courbes, et c'est même le nom qu'on leur donne dans un mémoire de l'Académie Royale des Sciences où on les propose comme un objet digne des recherches des géomètres ", are CLAIRAUT's words.

CLAIRAUT soon became interested in geodetic work, and in a paper of 1733 on this subject he came to the theorem on surfaces of revolution bearing his name; this theorem states that along a geodesic line C

$$\rho \sin \alpha = \text{const},$$

where ρ is the radius of the parallel circle and α the angle of C with that circle (23). Later he came to integrability conditions of differential equations in studies on hydrostatics. It deserves mention as a first step in what we now call PFAFF's problem. (24) He found that

$$Mdx + Ndy + Pdz = 0$$

is exact, when and only when,

$$M\left(\frac{\delta N}{\delta z} - \frac{\delta P}{\delta y}\right) + N\left(\frac{\delta P}{\delta x} - \frac{\delta M}{\delta z}\right) + P\left(\frac{\delta M}{\delta y} - \frac{\delta N}{\delta x}\right) = 0.$$

He actually proves that the condition is not only necessary, but sufficient.

LEONARD EULER's (1707-1783) work is so varied that it is hard, in this outline, to do him justice. From early youth he constantly turned to the application of the calculus to geometry, from work done in 1727 on parallel curves in the plane, (25) intersecting under constant angle to his paper of 1782, on the differential geometry of space curves. In a series of papers between 1728 and 1732 he takes up the problem of the geodesics

(23) A. C. CLAIRAUT, Détermination géométrique de la perpendiculaire à la méridienne tracée par M. CASSINI, Ib. 1733, publ. 1735, p. 406.

(24) The work dates from 1739 and 1740, see CANTOR III, p. 856, 861. See also CLAIRAUT's " Théorie de la figure de la terre, tirée des principes de l'Hydrostatique. Paris, 1743. German translation in *Ostwald's Klassiker*, no. 189.

(25) See for the literature F. MÜLLER, Über bahnbrechende Arbeiten L. EULERS aus der reinen Mathematik. *Abh. zur Geschichte d. Math. Wiss.* 25 (1907), p. 63-116, esp. 108-113, or CANTOR III and IV.

XUM

on a surface. JOHANN BERNOULLI had attracted his attention to it, probably through the aid of his nephew DANIEL, who was at St. Petersburg with EULER. A result was the equation of the geodesics, in the form

$$\frac{Qddx + Pddy}{Qdx + Pdy} = \frac{dx\,ddx + dy\,ddy}{dt^2 + dx^2 + dy^2},$$

where $Pdx = Qdy + Rdt$ connects the variables of the surface. (26) He made applications to several types of surfaces, for instance cones. In 1732 he uses the coordinates (x, s) in a discussion of the cycloid as a tautochrone. In the same number of the *Commentarii* this is also done by G. W. KRAFT. In 1736, in a paper on the tractrix, he introduces among other new coordinates arc length s and radius of curvature ρ as coordinates of a plane curves, and so opens the series of papers on intrinsic geometry. He shows how x and y can be found when ρ and s are given. In the *Mechanics* of 1736 he proves that mass points on a surface without a force field move along geodesics. In 1740 he studies evolutes and involutes, a study leading him, in 1764, to the curious result already announced by JOHANN BERNOULLI, that the n^{th} involute of a curve for increasing n tends to become a cycloid. With all these results it is rather astonishing that the *Introductio in analysin infinitorum*, the standard textbook EULER published in 1748, contains so little differential geometry. It may have been the intention of EULER to write a special book on this subject; (27) if so, it was never accomplished. The *Introductio* contains only some remarks on singular points and asymptotes of plane curves, and some osculation properties. EULER, writing the equation of plane curves in the form

$$0 = A\,t + B\,u + C\,t^2 + D\,t\,u + E\,u^2 + F\,t^3 + \ldots$$

A, B, C, D, ... constants

is first led to introduce an osculating conic section at the origin, which he approximates by a parabola, but then changes to the osculating circle. There are also some remarks on concavity and convexity in relation to the ambiguity of the sign of the radius of curvature. (28)

(26) JOHANN BERNOULLI had the equation also in 1728, printed in his Opera IV (1744) p. 108. Here the word " planum osculans " for the first time.

(27) See CANTOR III, p. 784.

(28) L. EULER, Introductio in analysin infinitorum, II, ch. XIV.

It is a remarkable fact that only in 1760 EULER opens an entire new field in differential geometry. All his previous work has been more in the way of elaboration of old results of LEIBNIZ and the BERNOULLIS, with the possible exception of the introduction of natural coordinates. Even CLAIRAUT's work has merit for differential geometry only as a statement of the problems. We must, however, make reservation for EULER's fundamental work on the calculus of variations, culminating in his *Methodus inveniendi lineas curvas maximi minimive proprietate gaudentes* of 1744, in which he not only states and gives methods of solutions to isoperimetrical problems, but finds interesting geometrical properties of curves. The best known perhaps is the theorem that the catenoid is a minimal surface. (29)

EULER's paper of 1760, *Recherches sur la courbure des surfaces*, (30) written during his Berlin residence, contains the first important contribution to surface theory, and also to three-dimensional differential geometry in general. So far only the existence of the tangent plane at a point of a surface had been established, and that in not a very satisfactory way (for instance, by CLAIRAUT). EULER here takes a definite step forward, and arrives at the so-called EULER theorem on curvature of surfaces. It states, in EULER's terms)

$$r = \frac{2fg}{f + g + (f - g)\cos 2\alpha},$$

where f and g are the extreme values of r, the radius of curvature of a normal section, and α is the angle of this normal section with one of the normal sections of extreme curvature. The form under which we know the theorem is due to DUPIN, but the name " section principale " is due to EULER, as well as the theorem that the two sections of extreme curvature are normal to each other. His demonstration starts with an arbitrary plane section through a point of the surface, then proceeds to an expression of the radius of curvature for this section, the expression being gradually simplified.

Shortly afterwards (1762) LAGRANGE (1736-1813), then a young

(29) L. EULER, Methodus inveniendi V, Ex. VII 47, German translation in *Ostwald's Klassiker*, 46, p. 111.

(30) Histoire de l'Académie royale des Sciences (Berlin), 1760, p. 119-141.

XUM

professor at Turin, published his famous paper on the calculus of variations, the main results of which he had already shown to EULER in 1755. In an appendix, he found the differential equations of the minimal surfaces in the form that p and q must be found under the condition that

$$p\,dx + q\,dy, \qquad \frac{pdy - qdx}{\sqrt{1 + p^2 + q^2}}$$

are exact differentials. (31)

In 1770 EULER continued his study of surfaces, and began to investigate developables. He represents the x, y, z of a point on a surface as functions of two variables t and u (the first time the so-called Gaussian variables are introduced), and writes down the conditions that

$$dx^2 + dy^2 + dz^2 = dt^2 + du^2;$$

$$l^2+m^2+n^2=1, \quad \lambda^2+\mu^2+\nu^2=1, \quad l\lambda+m\mu+n\nu=0$$

$$l=\frac{\partial x}{\partial t}, m=\frac{\partial y}{\partial t}, n=\frac{\partial z}{\partial t}; \quad \lambda=\frac{\partial x}{\partial u}, \mu=\frac{\partial y}{\partial u}, \nu=\frac{\partial z}{\partial u}$$

or, as he states, that

" Une considération tout à fait singulière m'a conduit à la solution de ce problème," he writes to LAGRANGE. EULER is able to integrate the equations and to show that the tangents to an arbitrary space curve form such a developable surface. (32) From his integral he does not seem, however, to draw the conclusion that such surfaces are the only real solution.

Differential geometry had advanced thus far when an entirely new development started. With the exception of EULER's papers and occasional work of LAGRANGE, very little had been done

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(31) J. L. LAGRANGE, Essai d'une nouvelle méthode pour déterminer les maxima et les minima des formules intégrales indéfinies. *Miscellanea Taurinensia* 1760-61, publ., 1762, p. 173-195. *Œuvres* I, p. 335-362. German translation in *Ostwald's Klassiker*, 47, p. 23.

(32) L. EULER, De solidis quorum superficiem in planum explicare licet. Nova Comm. Petrop. 16, 1771, p. 3-34. See EULER's letters to LAGRANGE of Jan. 16 and March 9, 1770, Œuvres de Lagrange XIV, p. 217, 218, 221-223, 224.

There is another paper of EULER's hand on surface theory, written in this time, between 1766 and 1775, but only published in 1862, Opera posthuma I, p. 494-496 : " Problema invenire duas superficies quarum alteram in alteram transformare licet, ita, ut in utraque singula puncta analoga easdem inter se teneant distantias." Here we find that surfaces are applicable if, in modern notation, E, F, G are equal, and the remark that a closed surface cannot be bent.

for a long time. Feudalism, in decay, could not send auxiliary forces to the aid of the lone genius. EULER, in many respects, represented this last period of the feudal system, which disappeared intellectually with such undeniable elegance. EULER's creations perhaps may find a counterpart in those of MOZART.

LAGRANGE felt it, "Ne vous semble-t-il pas" he wrote to D'ALEMBERT in 1772, " que la haute géométrie va un peu en décadence ? " He expresses the same view at other places and D'ALEMBERT's answers are sceptical. (33)

We can interpret the new life, which was developing at the military academy of Mézières, as the beginning of the influence of the French revolution on geometry. Here GASPARD MONGE (1746-1818) was professor since 1768, and began in that early time to show that fecundity in geometrical invention which made him the real creator of differential geometry, of descriptive geometry, and directly and indirectly, of modern geometry in general. His starting point was a series of questions on fortification, which led him to descriptive geometry, but he also knew how to use analysis. His first publication, in 1771, already showed the master. It deals with space curves, the first paper on this subject since CLAIRAUT treating this subject for its own sake. (34) It contains a broad exposition of the whole differential geometry of space curves. It is shown how such curves admit an infinity of evolutes, that they all lie on a developable surface, the polar developable, and that they are geodesics of this surface. He also introduces what we would call the rectifying developable and shows that the original curve is a geodesic on this surface. Here appears the normal plane, the radius of first curvature, the osculating sphere. Two types of inflexion exist : inflexion caused by (what we call) torsion zero, and inflexion caused by (what we call) curvature zero. In the first case, the " points de simple inflexion," four consecutive points of the curve lie in one plane, in the second, the " points de double inflexion," three consecutive points lie on a straight line. Several terms, since adopted, appear here

(33) Œuvres de LAGRANGE XIII, p. 229, 232, 237.

(34) G. MONGE, Mémoire sur les développées, les rayons de courbures et les différents genres d'inflexion des courbes à double courbure. *Mém. div. savans* 1785, p. 511-550 (written 1771), also last chapter of the " Applications de l'Analyse à la Géométrie," where only a part is reprinted.

for the first time, as " ligne des pôles," " arête de rebroussement," " developpée." Many applications to plane and space curves illustrate the general theorems.

In 1780 MONGE published a second paper, written in 1775 (35), in which he took up EULER's theory of developables. MONGE intends to simplify EULER's results. But in his hands the whole theory takes another shape. The geometrical part is treated in such a way as to make the great author of the *Recherches sur la courbure des surfaces* and of many more contributions to geometry more analyst than geometer. Nevertheless there is a good deal of the analyst in MONGE. But the formulas always follow the dynamics of geometrical development, so that the integration of a partial differential equation becomes the gradual building up of a geometrical system in space. Nobody except LIE ever equalled MONGE in this direction.

MONGE points out the essential difference between general ruled surfaces and developables, sets up the differential relation $rt - s^2 = 0$ and finds as first integral that there is an arbitrary relation between p and q, which means that a developable is always tangent surface to a space curve. It is also the envelope of a two parameter family of planes. Application is made to the tangent developable of two surfaces, which was already partly elucidated in EULER's work, but which as a problem of " ombres et pénombres " had a great attraction for the inventor of descriptive geometry. We also find here the differential equation of the third order for the ruled surfaces, with the solution of the problem of finding the ruled surface passing through three space curves.

The volume of the Mémoires des savans étrangers, of 1785, which contains MONGE's first paper, contains another classic of differential geometry, MEUSNIER's *Mémoire sur la courbure des surfaces*, written in 1776. (36) The title already shows the indebtedness of the author to EULER. MONGE had, indeed,

(35) G. MONGE, Sur les propriétés de plusieurs genres de surfaces courbes, particulièrement sur celles des surfaces développables, avec une application à la théorie des ombres et des pénombres. *Mém. div. savans* IX, 1780, p. 593-624 (written 1775).

(36) *Mém. sav. étrangers* 1785, p. 477-510. An exposition of MEUSNIER's paper not only in CANTOR IV, p. 547-550, but also in DARBOUX, Théorie générale des surfaces I (1887), p. 260-271.

recommended the paper of EULER to one of his pupils, JEAN BAPTISTE MEUSNIER DE LA PLACE (1754-1793), and, working under the direction of his teacher, the young officer not only found EULER's results in a new way, but added the results which for ever carry his name. In one of the principal sections of the surface at a point he draws a circle, tangent to the surface, with radius equal to the " rayon de courbure " at that point in that direction. This circle is rotated about an axis in its plane parallel to the tangent plane and at a distance equal to the second principal radius of curvature. In this way MEUSNIER gets a torus which has the first and second derivatives in common with the surface at the point. Then he takes this torus as representative of the surface and gets not only EULER's theorem, but also " MEUSNIER's theorem," which he interprets with the aid of a sphere tangent to the surface and with radius equal to the normal radius of curvature of the section in the arbitrary direction on the surface.

MEUSNIER uses his torus in finding the condition under which a surface be a minimal surface. LAGRANGE had already found the differential equation. MEUSNIER interprets it by showing that it means that the sum of the radii of principal curvature is constant. Then he interprets this equation by simple geometrical methods in two cases, and finds the twisted helicoid and the catenoid, which for many years were the only minimal surfaces known. EULER already had found the catenoid, but MEUSNIER, it seems, found his solution independently.

This paper remained the only contribution of MEUSNIER to mathematics. He published it under the best auspices; D'ALEMBERT, feeling the new spirit, said " MEUSNIER commence comme je finis." But MEUSNIER went to other spheres of activity, where he also did excellent work. He collaborated with LAVOISIER to separate water in its constituents (paper of 1784) and wrote important papers on the new subject of aeronautics. " Après avoir consacré sa trop courte vie aux recherches les plus neuves, les plus difficiles, les plus fécondes, il a trouvé devant l'ennemi, au siège de Mayence, la mort la plus héroique." (37)

(37) G. DARBOUX, Notice historique sur le général MEUSNIER, 1909. In " Éloges académiques et discours, Paris", HERMANN, 1912, p. 218-262. GOETHE describes how he watched the French soldiers, defeated, leaving Mayence. They carried the body of MEUSNIER away with them.

CHARLES TINSEAU (1749-1822) was also a graduate of the Mézières academy, class of 1771. He presented a paper to the Academy in 1774, which contains, among several fundamental contributions to the analytic geometry of space, the equation of the osculating plane to a space curve, the surface of the tangents to a curve (already introduced by CLAIRAUT), and the theorem that the orthogonal projection of a space curve on a plane has a point of inflexion if its plane is perpendicular to the osculating plane. (38)

In this period falls a charming paper by EULER, in which he investigates what we now call curves of constant breadth, in EULER's terms : " orbiformes." He gets them as involutes of " triangular curves," that are closed curves with three cusps. (39)

In the meantime MONGE had continued his productivity, of which we shall say more in the next chapter. We only mention a paper of 1781, *Mémoire sur la théorie des déblais et des remblais*, (40) which takes as starting point the engineering problem of moving a heap particle after particle from one place to another in a minimum of effort. This leads to line congruences, which admit two sets of developable focal surfaces. When these are normal, the congruence is normal to a surface, and cuts it along the lines of curvature. In this original way the lines of curvature were introduced into literature. Then there is another paper of 1784, in which he integrates the equation of the minimal surfaces. (41) There are more papers, equally fundamental; but as all are collected in his book of 1808, we may discuss them together. Since 1780 he had been living in Paris for six months a year, where he taught hydraulics at the Louvre, but after BEZOUT's death, 1783, he settled there permanently.

About this time the aging EULER again wrote a fundamental

(38) C. M. T. TINSEAU, Solution de quelques problèmes relatifs à la théorie des surfaces courbes et des courbes à double courbure. *Mém. div. savans* IX, 1780, p. 593-624.

(39) L. EULER, De curvis triangularibus. *Acta Petr.* 2 (1778), p. 3-30.

(40) *Mém. div. sav.* 1781 (publ. 1784). See P. APPELL. Mémorial des Sciences mathématiques XXVIII, also our footnote (50).

(41) G. MONGE, Une méthode d'intégrer les équations aux différences ordinaires. *Mém. div. sav.* 1784, p. 118. An improvement was suggested by LEGENDRE, l'Intégration de quelques équations aux différences partielles. *Mém. div. sav.* 1787, p. 311-12.

paper (42). It sets forth the first analytical treatment of the differential geometry of space curves. MONGE had treated the subjects from a geometrical point of view, but had not given an analytical frame. EULER provides for this by taking x, y, z as functions of the arc length s, and the direction coefficients of the three axes of the moving trihedron. For this purpose EULER introduces the spherical image, using the unit sphere as GAUSS did forty years later. The equation of the osculating plane is here given in the symmetrical form $x\,(rdq-qdr) + y\,(pdr-rdp) + z\,(qdp-pdq) = t$, where t is determined by the condition that the plane must pass through a given point of the curve. This symmetrical way of treating coordinates also characterizes other papers of EULER, as, for example, one of 1779, in which he writes the equation of the geodesic lines on a surface,

$$d^2x(qdz-rdy) + d^2y(rdx-pdy) + d^2z(pdy-qdz) = 0,$$

$$\text{where } pdx + qdy + rdz = 0$$

is the differential equation of the surface. In this paper the integration is carried out for rotation surfaces, partially repeating thereby results of CLAIRAUT. (43)

An account of the important work on map projection done in the 18th century, and again through the efforts of EULER and LAGRANGE, supported by LAMBERT is still missing in our report. All this work is carried out after 1770, the time of the revival of differential geometry in general. In 1777, EULER introduced complex numbers in his study of conformal projection, which LAGRANGE, in the same year, used for the more general problem of mapping meridians and parallels of a sphere into an arbitrary orthogonal system of plane curves. There is a discussion of this work by V. KOMMERELL in CANTOR's *Vorlesungen* IV, p. 572-576 and in books on cartography. Here, on p. 508-511, is also a discussion of work on parallel curves done in the same period (EULER, NIEUPORT, KÄSTNER, and others).

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(42) L. EULER, Methodus facilis omnia symptomata linearum curvarum non in eodem plano sitarum investigandi. *Acta Petr.* 1782, I, p. 19-57 (publ. 1786).

(43) L. EULER, Accuratior evolutio problematis de linea brevissima in superficie quacumque ducenda, *Nov. Act. Petr.* XV, 1779, p. 44-54.

4. — *Monge and the École Polytechnique.*

The French Revolution influenced scientific thought in all directions. Under its influence modern geometry was born. In algebraic geometry the strict prescriptions of Greek thought were discarded, and an entirely new school of reasoning was created. In differential geometry the mathematicians at last learned to apply the century-old thoughts of LEIBNIZ and the BERNOULLIS and to establish a science on collective work where EULER so long had pioneered alone.

GASPARD MONGE was uncontested leader. His political work was reflected in his scientific activity. During the revolution he joined the Jacobins, but like many of his political friends he later supported the Empire, which they interpreted as the executor of the will of the French Revolution. NAPOLEON entrusted to MONGE many important functions; he even made him for a while secretary of the navy. On the expedition to Egypt he had with him MONGE as well as many other famous scholars. But MONGE's life work became the organization and scientific leadership of the Ecole Polytechnique, of which he was the director from its beginning, in 1794, till the fall of the Empire. But the Restoration and the old Republican were irreconcilable, and MONGE had to resign. He died a few years later, closing a life not only crowded with scientific achievements but characterized by a unity of thought and deeds seldom found among scholars.

The importance of the Ecole Polytechnique for the development and the organization of science has so well been treated by FELIX KLEIN in his lectures on the history of mathematics in the 19th century (44), that we need not discuss it here. From the beginning MONGE's teaching was an integrating part of the instruction. Here his remarkable geometrical intuition went hand in hand with practical engineering applications to which his whole manner of thinking was always inclined. He also started a collection of models, later continued by TH. OLIVIER. He taught descriptive geometry as a new subject, and he collected his lessons in the

(44) F. KLEIN, Vorlesungen über die Entwicklung der Mathematik im 19. Jahrhundert, I. Berlin, SPRINGER, 1926, Ch. II. KLEIN refers to JACOBI's paper. Werke 7, p. 355-370.

Géométrie descriptive, which still is a standard treatise. He taught differential geometry in the same way; these lessons appeared first as loose pamphlets, the *Feuilles d'Analyse appliquée à la Géometrie* (since 1795), then, in 1807, with little modification, as a book, *Applications de l'Analyse à la Géometrie*. The lessons show all the characteristics of MONGE's genius. (45)

Those who are interested in a discussion of the *Feuilles d'Analyse* can find the material in KOMMERELL's paper in CANTOR IV. We will here discuss the main line of the *Applications*, which however differ but slightly from the *Feuilles*.

The leading thought of the book is the geometrical interpretation of partial differential equations and the interpretation of geometrical facts into the language of partial differential equations. For this MONGE develops the theory of envelopes, characteristics, and edges of regression. At the same time he shows what the integration process means in space.

As the simplest example let us take Chapter II on cylindrical surfaces. These surfaces can be considered in different ways. If we look at them as surfaces of which the tangent plane is parallel to the generating line and therefore parallel to the direction $x = az$, $y = bz$, we get as the equation $ap + bq = 1$, (p and q are the symbols $p = \frac{\delta z}{\delta x}$, $q = \frac{\delta z}{\delta x}$).

But cylindrical surfaces are also surfaces of which the generating line is always parallel to the line $x = az$, $y = bz$. This gives as equation $y - bz = \varphi(x - az)$, where φ is an arbitrary function. In this way we get the integral of $ap + bq = 1$. From this we can solve several other problems, as the determination of the cylindrical surface if the direction of the generators and a space curve directing their motion is known, or the determination of a surface that envelops a surface along a given curve. At the same time this shows the manipulations which may be effected with partial differential equation.

In this way every chapter of the *Applications* is built up. MONGE classifies his problems into those leading to partial differential equations of the first order, of the second order, and the third

(45) The most interesting edition is the fifth, with notes of J. LIOUVILLE, 1850. The " Feuilles d'Analyse " appeared again in 1801.

order. To the first category belong the cylinders, the cones, the canal surfaces; to the second, the developables ($rt - s^2 = 0$), the ruled surfaces with generators parallel to a given plane, and to the third category, the ruled surfaces.

But to the second category belongs also that whole class of surfaces whose curvatures satisfy certain simple conditions. MONGE is, starting in 1784, the first to introduce the lines of curvature and their properties (41). In a clever way he integrates (Ch. 16) the lines of curvature on an ellipsoid, by increasing the order of the differential equation. He then solves the following four problems :

1) surfaces with one set of lines of curvature plane (Ch. 17)
2) surfaces with $R_1 = \text{const}$ (Ch. 18)
3) surfaces with $R_1 = R_2$ (Ch. 19)
4) surfaces with $R_1 = -R_2$ (Ch. 20)

Problem 1) leads to the molding surfaces (" surfaces moulures "), 2) to the tube surfaces, 4) to the minimal surfaces. But in 3) MONGE finds the paradoxical result that the sphere alone is a solution. In 3) and 4), he integrates the equations in full, and this shows him the explanation of the paradox. There is, indeed, an extended class of families answering problem 3). But the sphere is the one real surface. All other surfaces are imaginary with one real curve on each. These surfaces, says MONGE, are really curves, with area everywhere zero. This is the first full discussion of imaginaries in geometry.

MONGE, however, does not give any other special cases of his general equations of the minimal surfaces than the two known since MEUSNIER.

Another example of a problem leading to a partial differential equation of the third order is the problem of the spheres of variable radius with centers on a space curve (Ch. 22). If the radius is constant the problem is of the second order, if the curve, besides, is plane, it is of the first. The methods used, in all cases, follow the same line of thought.

The last chapters deal with another problem at which MONGE arrived by noting that the normals to a surface along the lines of curvature form a developable surface. This new problem is the inverse one; to find the surfaces of which the normals are tangent to a given surface.

From these lectures many words remained standard expressions. Besides those mentioned, we have: " lignes de courbure, " " enveloppe," " charactéristique," and the notation p, q, r, s, t for the partial derivatives. But not only MONGE's differential geometry, also his descriptive geometry has a bearing on our subject. It deals with curves and surfaces, but in a purely constructive way, without formulas. Two ways are thus indicated as methods of attacking geometrical problems on curves and surfaces, the geometrical and the analytical. We see this separation clearly in work of MONGE's pupils, as for example DUPIN, who proves many theorems twice, both by geometry and by analysis. In our present day differential geometry we still show that influence, when we define lines of curvature, asymptotic lines, conjugate lines in two different ways. From this " descriptive " type of geometry, which MONGE taught, projective geometry emanates in the hands of his pupils.

MONGE's general idea of connecting partial differential equations with geometry of space is still a leading method in differential geometry, especially in France. In a modernized way, though only through indirect influence, it dominates the work of SOPHUS LIE.

5. — *Monge's Pupils*

A galaxy of brilliant men supported MONGE at the Ecole Polytechnique either as colleagues or as pupils. A school of mathematics was the result, in which analytical geometry and differential geometry flourished, and in which projective geometry was created. A stimulating influence had the necessity of teaching courses on advanced subjects, and there was a regular output of textbooks on mathematics and mechanics, many of which established standards valid till today. Almost all geometry was threedimensional. Our theory of quadric surfaces dates from those times, and a considerable attention was paid to plane and space transformations.

Common to all these scientists was their contact with practice, either in the abstract form of mathematical physics and mechanics, or in the direct form of engineering and economic or political activity. They represented one phase of the emancipation of

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the French bourgeoisie. NAPOLEON expressed also their ideas when he wrote to LAPLACE : " L'avancement, le perfectionnement des mathématiques sont liés à la prospérité de l'état."

Among the colleagues of MONGE of mature age we find LAGRANGE and LAZARE CARNOT; among his younger colleagues and pupils, FOURIER, AMPÈRE, POISSON, PONCELET, RODRIGUES, LANCRET, CORIOLIS, MALUS, DUPIN, FRESNEL, CAUCHY, SADI CARNOT, SOPHIE GERMAIN. For our purpose we must examine closely the work of AMPÈRE, LANCRET, MALUS, RODRIGUES, and especially that of DUPIN.

A. M. AMPÈRE's (1775-1846) mathematical discoveries are less remembered than his physical, though a certain type of partial differential equation carries his name. He commenced his main physical work only after OERSTED's discovery in 1820 of the influence of the electric current on a magnetic needle, when he was already famous as a mathematician. For us a paper on osculating parabolas (46) is of importance, because it contains the notion (if not the name) of the differential invariant. AMPÈRE recognises the importance of ρ and s as instrinsic coordinates of a plane curve, but remarks that s still depends on an arbitrary constant. Therefore higher derivatives are necessary for truly intrinsic coordinates. He chooses for this the osculating parabola. When its equation with respect to tangent and normal at a point of the curve is $u^2 = pt$, (p the parameter), the curve can be given as a function between u and t. He shows that u, p, t are differential invariants under rotations and translations. They depend on third derivatives; and AMPÈRE approaches affine differential geometry, when he finds the condition for points with parabola osculating in five consecutive points (affine curvature zero, as we say now) (47). To similar contact with affine conceptions came LAZARE CARNOT (1753-1823) who, in his *Géométrie de position* of 1803, defined what we now call the affine normal. He also proposed intrinsic coordinates, the radius of curvature, and the angle of affine normal with the ordinary normal, as in AMPÈRE's case a mixture of affine

(46) A. M. AMPÈRE, Sur les avantages qu'on peut retirer, dans la théorie des courbes, de la considération des paraboles osculatrices, avec des réflexions sur les fonctions différentielles dont la valeur ne change pas lors de la transformation des axes (presented 1803). *Journal Ec. Polyt.* 14e cah. (1808), p. 159-181.

(47) See p. 178 of AMPÈRE's paper.

and metric conceptions, which could not be very fertile. (48)

That there were many discussions on intrinsic coordinates in those days is also seen in S. F. LACROIX' much used textbook in three volumes on differential and integral calculus, which in its first volume has more than 250 pages on curves and surfaces. He deals faithfully with all results obtained by EULER, MONGE, MEUSNIER, LAGRANGE and others. He also discusses the suggestions of CARNOT and AMPÈRE, and mentions other ways to study curves independent of their position in the plane. (49)

E. L. MALUS (1775-1812) is famous as the discoverer of the polarization of light (1808). His investigations in optics lead him, as later HAMILTON, to the study of line congruences. This theory dates from MONGE's work of 1781 on " déblais and remblais " (50), but MALUS establishes again with his methods the theorem that in such a congruence each line is in general cut by two other lines, so that the lines are the intersection of two families of developpable surfaces. The application to normals to a surface establishes the theorem on lines of curvature. MALUS studies the behavior of line congruences under reflection and refraction. He also studies what we now call line complexes. Through a mistake he fails to obtain entirely the "MALUS-DUPIN" theorem. (51)

With MICHEL ANGE LANCRET (1774-1807) we have a young, promising scholar, who died too early to fulfil his promises. He belonged with MONGE, FOURIER, AMPÈRE, GEOFFROY ST. HILAIRE and many others, to the scholars who accompanied NAPOLEON on his Egyptian expedition. Later he became a member of the commission appointed to publish the results, but he died at

(48) L. N. M. CARNOT, Géométrie de position. Paris, 1803, 489 p., see Probleme LXXVI, art. 433, p. 477, and art. 432, p. 475-476.

(49) S. F. LACROIX, Traité du calcul différentiel et du calcul intégral. Tome I, Paris. Seconde éd. 1810, 652 p., espec. no. 255, p. 484-485. From AMPÈRE's paper it seems that LACROIX in the first edition of his book started the discussion. The work was continued by GERGONNE, *Annales de mathémathiques*, 4 (1813-14) p. 42-55. GERGONNE, p. 372 of the same volume, in restating some results of DUPIN, frames the term " tangentes principales ".

(50) See note (41), also C. SEGRE, MONGE e le congruenze generali di rette. *Bibliotheca mathematica* 318 (1907-08).

(51) MALUS, Optique, *Jour. Ec. Polyt.* 14 cah., 1808, p. 1-44; Dioptrique, ib., p. 84-129; Traité d'Optique, *Mémoires présentés à l'Institut* 2 (1811), p. 214-302, cont. p. 303-508 as " Théorie de la double réfraction."

33 years of age. He wrote two mathematical papers, (52) the first on the general theory of space curves, the other (published after his death) on " développoides," space curves whose tangents are lines cutting a given space curve under a constant angle different from 90°. His first paper is of a more general nature. It contains the two fundamental quantities of the space curve, which he calls " première flexion " and " seconde flexion." The first is the angle $d\mu$ of two consecutive normal planes, the second the angle dv of two consecutive osculating planes. (53) Curvature and torsion appear therefore as differentials, and are not written as finite quantities until CAUCHY. There is a third quantity, the angle $d\omega$ of two " plans rectifians " (this name and conception also appears here), and the " equation of LANCRET " exists :

$$d\mu^2 + dv^2 = d\omega^2$$

which shows that only two of the three quantities are independent. As an application we learn that the first flexion of the " développante " is equal to the second flexion of the " développée," and vice versa, a theorem only correct for the differentials.

LANCRET is therefore the first to take up the systematic theory of space curves after EULER, but it seems in an independent way. The line of progress goes here from CLAIRAUT via EULER and LANCRET to CAUCHY and FRENET.

OLINDE RODRIGUES (1794-1851) did some work on lines of curvature, simplifying MONGE's results. A set of important formulas still is called after him (54), and so a formula in the theory of LEGENDRE functions. He found also what we now call the Gaussian curvature of a surface by comparing an element of surface with its spherical image; he missed, however, the " theorema egregium." He later became acquainted with ST. SIMON

(52) M. A. LANCRET, Mémoire sur les courbes à double courbure. *Mémoires présentés à l'Institut* 1 (1806), p. 416-454 (presented 1802); Mémoire sur les développoides des courbes planes, des courbes à double courbure et des surfaces développables, ib., 2 (1811), p. 1-79, presented 1806.

(53) LANCRET says that he got his ideas from FOURIER (p. 420). FOURIER did not publish it himself.

(54) O. RODRIGUES, Recherches sur la théorie analytique des lignes et des rayons de courbure des surfaces, et sur la transformation d'une classe d'intégrales doubles, qui ont un rapport direct avec les formules de cette théorie. *Correspondance sur l'Ec. Polyt.* 3, 1815, p. 162. Also a paper in *Bull. Soc. Philomatique* Paris, (3) 2, 1815, p. 34-36: «Sur quelques propriétés des intégrales doubles et des rayons de courbure des surfaces." Here the name is given as *Rodrigue*.

and did considerable work to propagate the socialistic theories of his master, which prevented him from work in mathematics.

CHARLES DUPIN (1784-1873), since 1824 Baron DUPIN (many eminent mathematicians were given titles of nobility in those days, a custom introduced by NAPOLÉON; MONGE, for instance, became " comte de Pélouse ") is the most important differential geometer among the direct pupils of MONGE. Many of his discoveries were made long before he published them in this books, the delay being partly due to his many duties as a naval officer, some of which carried him " dans des pays presque barbares," such as Corfu. At the age of sixteen he discovered the " cyclide of DUPIN ", (55) about 1807 the " DUPIN theorem " on orthogonal surfaces. His results were collected in the *Développements de géométrie* (1813), later followed by the more applied mathematical *Applications de géométrie et de mécanique* of 1822. (56) The *Développements*, he explicitly stated, have been written as a sequel to MONGE's books. MONGE's two methods of approach, the descriptive and the analytical, appear as different currents in DUPIN's book, half of which is purely geometrical, and half of which uses analysis. These tendencies were soon afterward to grow into entirely different branches, into projective geometry and differential geometry proper. DUPIN therefore in almost all cases proves his theorems in two different ways, geometrically and analytically, again following MONGE who defined lines of curvature geometrically as lines along which the normals form a developable surface and analytically as lines along which the normal curvature has extreme value.

The *Développements* are divided into two sections. The first section contains the theory of the indicatrix, the second of the orthogonal systems of surfaces. The main discoveries of the first section are asymptotic lines and the conjugate sets; that of the second section, " DUPIN's theorem " on the lines of intersection of triply orthogonal systems. This enables the author

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(55) See J. BERTRAND, Éloges académiques. Paris, Hachette, 1890, p. 221-246.

(56) CH. DUPIN, Développements de géométrie, avec des applications à la stabilité des vaisseaux, aux déblais et remblais, au défilement, à l'optique, etc. Théorie. Paris 1813.

CH. DUPIN, Applications de géométrie et de mécanique à la marine, aux ponts et chaussées, etc., pour faire suite aux développements de géométrie. Paris, 1822.

to give a new treatment of MONGE's lines of curvature on an ellipsoid by introducing confocal quadrics. The general theory of the indicatrix leads to a discussion of elliptic, hyperbolic and parabolic points, and throws new light upon the lines of curvature and the umbilics. DUPIN even enters into a discussion of the simplest cases of lines of curvature through an umbilic (guided by their behavior on an ellipsoid), and he gives the first geometrical proof of MONGE's theorem that the sphere is the only real surface with only umbilics.

From DUPIN's book date several names, as asymptotic lines, and conjugate directions, and also the modern form of writing EULER's equation,

$$\frac{1}{R} = \frac{\cos^2\alpha}{R_1} + \frac{\sin^2\alpha}{R_2}$$

DUPIN continued his research in the *Applications*, where he attacked many problems in applied fields, as stability of floating bodies, optics, and " déblais et remblais." Here, moreover, we also find the correction of " MALUS-DUPIN's theorem " on normal systems of straight lines, and the " cyclide " of DUPIN. (57)

DUPIN lived to a ripe age, but did not continue his work on geometry. His travels led him to many countries, and he became especially interested in the growth of capitalism in England, which he liked to propagate in France. This he did in a great number of papers and books on social subjects. He entered politics, became " pair de France " under the Restauration and " sénateur."

As representative of the purely geometrical school of MONGE in the time of the Restoration we have LOUIS L. VALLÉE (1804-1864), a prominent civil engineer, who wrote a *Traité de géométrie descriptive* in 1819, reprinted in 1825, and dedicated to MONGE. It contains the theory of space curves and surfaces, showing how their theory is built up by geometrical reasoning. Here we find for the first time the word " angle de courbure " together with " angle de torsion." VALLÉE reveals to us why geometry should be studied, quoting MONGE : " Pour faire fleurir l'industrie française, il faut diriger l'éducation nationale vers la connaissance

(57) MALUS-DUPIN's theorem on p. 191, with a criticism of MALUS. See for the history DARBOUX, Surfaces II, p. 280.

des objets qui exigent l'exactitude," and remarks that DUPIN " indique, comme une cause remarquable des succès manufacturiers de l'Angleterre, les soins qu'on donne à l'instruction des ouvriers anglais." (58) It is no accident that we see so many geometers of the Napoleonic time, — MONGE, DUPIN, RODRIGUES, VALLÉE — interested in industrial problems. JACOBI's contention that the only goal of science is the honor of the human mind belongs to a generation already emancipated from the revolution.

We must devote a few remarks to the *Théorie des fonctions analytiques*, in which LAGRANGE, in the first years of the Ecole Polytechnique, tried to build up calculus without the use of infinitesimals (1797). As his main object is the study of " dérivées " $f'(x)$, $f''(x)$, etc. (notation and name appear here for the first time) he is attracted by the contact of curves and surfaces. In this book therefore we find for the first time an elaborate analytical theory of osculation, illustrated by many examples. It served as model to all later expositions of the subject, together with that of CAUCHY.

As the last representative of this school we have therefore to mention A. CAUCHY (1798-1857), who became professor at the Ecole Polytechnique as a royalist, in 1816. He wrote on differential geometry in one of his textbooks (1826) " destiné à faire suite au Résumé des leçons sur le Calcul infinitesimal." (59) This textbook contains a beautiful exposition of the theory as it stood in CAUCHY's time at Paris, and shows in many respects the characteristics of CAUCHY's genius. Like LAGRANGE, another analyst, CAUCHY devotes special attention to the contact of curves and surfaces, and gives a first geometrical definition of the contact of two curves. He takes a point in common with two curves, draws a small circle of radius i with this point as center, considers the angle w intercepted on the circumference by the two curves, and compares w to a power of i. As source of inspiration in many details he mentions " les lumières de M. M. AMPÈRE et CORIOLIS." AMPÈRE's investigations on electric currents, indeed, inspired CAUCHY's discrimination between a right-handed and

(58) L. VALLÉE, Traité de géométrie descriptive. Sec. ed. 1825, p. 296-287.

(59) CAUCHY, Leçons sur les applications du calcul infinitésimal à la géométrie. Paris, I (1826), 400 p.; II (1828), 123 p. In this book the word " normale principale " is used (I, p. 285, 298).

a left-handed system of coordinate axes. Other innovations are the use of polar coordinates for the computation of the radius of curvature, the introduction of the " première courbure " $\frac{1}{r}$ and the " seconde courbure " $\frac{1}{R}$ for space curves, a systematic treatment of space curves and the use of the " rayon vecteur." It is entirely clear that CAUCHY used to the fullest extent all previous sources, especially MONGE and DUPIN. (60)

(to be continued.)

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Cambridge, Mass, D. J. STRUIK.

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(60) Of a certain importance is also the work of TH. OLIVIER (1793-1853), a lieutenant of artillery, who was called to Sweden to found a school after the pattern of the Ecole Polytechnique, and later became professor of descriptive geometry at Paris. He continued MONGE's tradition in his collection of geometrical models, and wrote several papers on differential geometry, e.g., a " Mémoire de géométrie," *Journ. Ec. Polyt.*, cah. 24 (1835), p. 61-91, in which he studies the circular helix having, at a point of a space curve, curvature and torsion equal to the corresponding quantities of the curve.

The history of mathematical time

I

Introduction

The problem of Time is one of the most difficult and elusive in the entire domain of natural philosophy. It has occupied the attention of philosophers in every branch of learning since the dawn of thought. References to the problem, in one or other of its many forms, are to be found in the philosophical writings which have come down to us from the earliest civilisations.

The problem has been left in its entirety practically untouched by the progress of Science and Philosophy : It is to this day as much open to thought and speculation as it was in the early times, when fundamental problems first began to engage attention.

A large part of the domain of modern mathematical physics makes use of the concept of Time : Such recent developments as the Theory of Relativity employ the concept as a fundamental : Nevertheless, we are still far from possessing a clear idea of the Nature of Time, which alone can enable us to grasp the true connexion between mathematical physics and Reality.

An historical study of the subject of Mathematical Time, as employed in modern science, reveals much of interest and value, not only to the mathematician, but also to the philosopher, with whom the mathematician becomes closely related in his quest for knowledge concerning the ultimate nature of existence.

In the following essay we endeavour to trace the birth and subsequent evolution of the concept of Mathematical Time.

I. — *Origin and Meaning of Mathematical Time*

The concept of mathematical Time may be regarded as having

its origin in the philosophical principles which form the basis of classical dynamics and certain branches of pure mathematics. These developments first showed the necessity for regarding Time as a continuum which might be identified with number, in accordance with the Pythagorean doctrine.

History seems to indicate that this view of Time was introduced during the renaissance of mathematics which took place in the seventeenth century. At this point of history the idea of Time is closely bound up with Space and Motion : Thus, JOHN NAPIER (1550-1617), Baron of Merchiston in Scotland, and inventor of logarithms, writes in his *Mirifici Logarithmorum Canonis Descriptio* of 1614 : "*Logarithmus ergo cuiusque sinus, est numerus quam proxime definians lineam, quae aequaliter crevit interea dum sinus totius linea proportionaliter in sinum illum decrevit, existente utroque motu synchrono, atque initio aequiveloce.*"

The early discoveries of NICOLAUS COPERNICUS (1473-1543), GALILEO GALILEI (1564-1642) and JOHANNES KEPLER (1571-1630) in the domain of stellar dynamics depended upon the observations of phenomena occasioned by changes in the motions of components of material systems. The conception of Motion, fundamental to the science of dynamics, clearly involves a notion of Time, and the classical mechanics of GALILEO and NEWTON employ this concept, together with their fundamental concepts of Force, Mass, Space and Time.

Considerable attention was given to the problem of Time by GOTTFRIED WILHELM LEIBNIZ (1646-1716), for whom "Space is purely relative as also time is. Space is an order of co-existence as time is an order of successions. Space marks in terms of possibility an order of things which exist in the same time so that they exist together. The manner of their existing is not in question." This view originated in the correspondence between LEIBNIZ and Dr. SAMUEL CLARKE, NEWTON's disciple, who was commissioned by NEWTON to defend the Newtonian concept of the sensorium, which had been attacked by LEIBNIZ in a letter to the Princess of Wales, afterwards CAROLINE, Queen Consort to GEORGE II, in 1715.

The views of LEIBNIZ concerning Time are not expressly stated in his published works; they are to be found mainly in various letters to ARNAULD, DES BOSSES, CLARKE and other of his

contemporaries, and do not appear at any stage in direct relation to mathematics. (1)

In his theory of Monads, both space and time are regarded as our sensuous apprehension of the order of the monads : Thus Space is the order of co-existing phenomena, and Time is the order of succession of phenomena. Space and Time are thus *entia mentalia*, in contradistinction to ponderable bodies and actual events, which are *entia semimentalia*, or *phenomena bene fundata*. By this distinction LEIBNIZ seeks to establish that Space and Time are pure abstractions : They are not real entities nor attributes thereof, but merely orders of co-existing and successive phenomena respectively. Thus in LEIBNIZ' philosophy Time is the order of succession of phenomena; it is regarded as an ideal continuum relating to existing phenomena, and by means of which existing phenomena or entities which are otherwise incompatible may be represented. It is seen, therefore, that Time is a system of connexion between the succession of phenomena; apart from which it must be regarded as a pure abstraction. Thus pure time is twice removed from reality, or *phenomena bene fundata*, since the phenomena which occupy time are abstract perceptions having their basis in *materia prima* and not monads.

In the formation of his *methodus calculi differentialis*, which was a *methodus incrementorum*, as compared with NEWTON's *methodus fluxionum*, LEIBNIZ avoided the difficulties concerning Time which NEWTON encountered in connexion with his ' method of fluxions.' Foremost in the controversy which followed the introduction of fluxions was GEORGE BERKELEY (1685-1735), Bishop of Cloyne in Ireland. In his " Treatise Concerning the Principles of Human Knowledge " (2) he says that " Time, Place and Motion, taken in particular or concrete are what everybody knows; but, having passed through the hands of a metaphysician,

(1) These letters have been reproduced in certain works dealing especially with LEIBNIZ, among which may be noted :

J. E. ERDMANN, " G. G. Leibnitii opera philosophica quae extant latina, gallica, germanica omnia," Berlin, 1840.

C. J. GERHARDT (Herausgegeben von), " Leibnitzens mathematische Schriften," Berlin und Halle, 1850-63.

C. J. GERHARDT (Herausg. von), " Die philosophischen Schriften von G. W. Leibniz." Berlin, 1875-90.

(2) Dublin 1710. London 1734. Sectns. 97, 98.

they become too abstract and fine to be apprehended by men of ordinary sense... For my own part, whenever I attempt to frame a simple idea of *time*, abstracted from the succession of ideas in my mind, which flows uniformly, and is participated by all beings, I am lost and embrangled in inextricable difficulties. I have no notion of it at all : only I hear others say it is infinitely divisible, and speak of it in such a manner as leads me to harbour odd thoughts of my existence : since that doctrine lays one under an absolute necessity of thinking, either that he passes away innumerable ages without a thought, or else that he is annihilated every moment of his life : both which seem equally absurd."

It seems necessary to remark that BERKELEY is here attacking the contemporary mathematicians. In the domain of mathematics BERKELEY is a realist, and his writings on the subject are, practically without exception, directed against accepted principles. In this connexion, his part in the protracted controversy on the differential calculus and other mathematical subjects is well known. In his "*De Motu : sive de motus principio et natura, et de causa communicationis motuum*" of 1721, BERKELEY remarks "Sed hujusmodi minutius distineri piget. Satis sit fontes solutionum indicasse : ad quos etiam illud adjungere libet : quod ea quae de infinita divisione temporis et spatii in mathesi traduntur, ob congenitam rerum naturam paradoxa est therias spinosas (quales sunt illae omnes in quibus agitur de infinito) in speculationes de motu intulerunt. Quidquid autem hujus generis sit, id omne motus commune habet cum spatio et tempore, vel potius ad ea refert acceptum." These remarks refer to the early Newtonian doctrines associated with the method of fluxions, although NEWTON had previously stated in the "*Tractatus de Quadratura Curvarum*" of 1704 a renunciation of infinitesimals in the following terms : "Considerando igitur quod quantitates aequalibus temporibus crescentes et crescendo genitae, pro velocitate majori vel minori qua crescunt ac generantur evadunt majores vel minores; methodum quaerebam determinandi quantitates ex velocitatibus motuum vel incrementorum quibus generantur; et has motuum vel incrementorum velocitates nominando Fluxiones, et quantitates genitas nominando Fluentes, incidi paulatim annis 1665 et 1666 in Methodum Fluxionum qua hic usus sum in Quadratura Curvarum" (ex Introductione).

BERKELEY overlooks NEWTON's change of thought, and compares contradictory statements from the *Principia* of 1687 and the *Quadratura* of 1704. The conceptions underlying the theory of fluxions suffered much aberration in consequence of these controversies, as is amply attested by the following passage from W. EMERSON's " Fluxions " of 1757 : " Here a metaphysical Disputant may demand, how it comes to pass, that any Velocity which *continues* for no Time at all, can possibly describe any Space at all : or whether its Effect be absolutely nothing, or an infinitely small quantity, or what it is. Here then it is, that our Reason is at a Stand, and the human Faculties are quite confounded, lost and bewildered. We are puzzled and perplexed by endeavouring to examine into the Nature of *we do not know what*, nor whether it is something or nothing : And at best it is some such subtile, fleeting Thing, as the Mind can lay no Hold on, nor form any Idea of. Now whether such subtile questions will be ever determined, or not, there is one Refuge for us, *viz*, that it is nothing at all to our Purpose what they are : And therefore we may safely leave these deep speculations to those that have more Business with them."

This represents a neat statement of the difficulty so far as it concerns the notions underlying mathematical speculations. EMERSON carefully avoids entry into a discussion of the difficulty, which would inevitably have led to the domain of philosophy. In EMERSON's time mathematicians had to use great care and circumspection in their statements, since, as we have already seen, the philosophers were ever ready to attack ideas which, although belonging to a different science, seemed out of accord with accepted philosophical principles. It was with the object of avoiding such difficulties that JEAN-LE-ROND D'ALEMBERT (1717-1783) introduced his famous method of Limits, by means of which the fundamentals of the differential calculus are usually presented to students of mathematics.

In what follows we shall consider as mathematical any department of temporal theory which has reference to pure or applied mathematics, or to physical phenomena which may be expressed mathematically.

XUM

II. — *Theoria Temporis Mathematicae of Isaac Barrow*

The first writings of direct mathematical interest in connexion with the problem of Time were made by ISAAC BARROW (1630-1677), first Lucasian professor of mathematics in the University of Cambridge. The professorial lectures of BARROW were attended by the illustrious NEWTON, and these two great mathematicians became closely acquainted. The life of BARROW, though very little known, is of great interest and inspiration, as is also the story of his acquaintance with NEWTON. BARROW was entered at St. Peter's College (now Peterhouse), Cambridge, on December 15th, 1643. Before he became qualified to reside in college, his uncle, also named ISAAC, a Fellow of St. Peter's, was ejected for writing against the Covenant, and BARROW consequently went as a pensioner to Trinity College. At this time his father lost all in the royal cause and, but for the kindness of one HENRY HAMMOND it is probable that he would have been obliged to leave Cambridge. In 1647 he was elected a scholar of Trinity, of which society he became a Fellow in 1649, the year following his receipt of the B. A. degree. There is no record of his order of merit in this examination. In 1652 he was made M.A., and in the following year received the same degree from Oxford. In June, 1655, BARROW set out on an extensive foreign tour, undertaken largely on account of friction during the difficult political times at Cambridge. He visited Paris, Florence, Smyrna and Constantinople, where he studied the works of ST. CHRYSOSTOM during a stay of more than a year in Turkey. He returned home by way of Venice, Germany and Holland, arriving in England in 1659, when he was ordained by Bishop BROWNRIGG, in accordance with the necessity of taking holy orders within seven years from the receipt of the M.A. degree.

At the Restoration, BARROW's fortunes improved, and he was appointed to the professorship of Greek at Cambridge in 1660, on the resignation of WIDDRINGTON. He began lecturing on the ' Rhetoric ' of ARISTOTLE, but we are told that he was not very successful as a Greek lecturer : which is hardly surprising in view of the low state of Greek learning at the time.

On the death of Mr. ROOKE, BARROW was made professor

of Geometry at Gresham College in London, in July 1662. On the 15th of July, 1663, he preached the consecration sermon in Westminster Abbey on the occasion when his uncle, ISAAC BARROW, was made Bishop of St. Asaph. In the same year he was appointed the first occupant of the Lucasian professorship of mathematics at Cambridge in the chair set up under the will of HENRY LUCAS of St. John's College, at one time Member of Parliament for the University. BARROW was also among the first members selected by the Royal Society after the grant of their Charter in 1663.

The Inaugural Oration on his commencement of the Lucasian professorship was delivered in Latin, as where the whole of the lectures, before the university on March 14th, 1664.

In this oration we find the first indication of his interest in temporal phenomena, as a mathematician. In referring to the uses we derive from mathematics he says that therefrom " we aptly digest the flowing series of Time, distinguish what is acted by due Intervals, rightly account and discern the various returns of the Seasons, the stated Periods of years and months, the alternate increments of days and nights, the doubtful limits of light and shadow, and the exact differences of hours and minutes." The conclusion of the address is typical of BARROW : He alludes to the tedium of an " empty Oration " of two hours length, and says, " But if I find it to have been very disagreeable to you, I shall easily comfort, even congratulate myself with this strong argument and certain augury, that I have to-day performed the part of an accomplished Mathematician, i.e. a most wretched Orator, I have done."

In the course of his duties as Lucasian professor, BARROW came into immediate touch with ISAAC NEWTON, whom he examined in Euclid in 1664 in connexion with a mathematical scholarship at Trinity College, where NEWTON had been a sub-sizar since 1661. It was due to BARROW's report on NEWTON's weakness in Euclid that NEWTON was led to reconsider this work, which he had previously regarded as a " trifling book." Thus commenced an association between the two men which was to prove of the greatest value to posterity. It is known that NEWTON possessed a copy of BARROW's *Euclidis Elementorum* of 1655. He probably also attended many of BARROW's lectures, and it is difficult

to overestimate the importance of this association in connexion with NEWTON's subsequent work. The fact that BARROW must have been greatly impressed by NEWTON is evident from the fact that on his resignation from the Lucasian professorship in 1669 he secured the appointment of NEWTON in his place, after having been known to express the fear of spending too much of his time on mathematics at the expense of his studies in divinity.

In the year 1669 BARROW composed his famous Exposition of the Creed, which has been described as sufficient in itself to ensure immortality for its author. Also in this year appeared his *Lectiones Opticae*, which are dedicated to the executors of HENRY LUCAS. These lectures were read by the famous mathematician, JAMES GREGORY (1638-1675) of St. Andrews and Edinburgh, author of the *Exercitationes geometricae* of 1668, who expressed to JOHN COLLINS his opinion that BARROW's was the best geometrical work he had seen. In 1670 appeared a second edition of the *Lectiones Opticae*, with which were included the famous *Lectiones Geometricae*, afterwards published as a separate work. The poor reception of these works seems to have turned BARROW's thoughts towards divinity, whither he had always possessed strong inclinations.

In 1670 BARROW was created D.D. by Royal mandate of CHARLES II, and in 1672 was appointed Master of Trinity College. In 1675 he was chosen Vice-Chancellor of Cambridge University, in the same year publishing an edition of the *Conics* of APOLLONIUS, and the extant works of ARCHIMEDES and THEODOSIUS. This was the last mathematical work of which BARROW witnessed the publication. He died in London on May 4th, 1677, and was buried in Westminster Abbey, to the West Side of Poets' Corner, where there is a marble memorial, surmounted by his bust, and bearing a Latin eulogy written by his friend Dr. JOHN MAPLETOFT, a professor of Gresham College.

This slight sketch of BARROW's achievements in the sphere of learning enables us to appreciate the range and depth of his knowledge, and his abilities as an original thinker. In addition to being one of the greatest of the great divines of the Caroline period he was widely read in the philosophy of the ancients and of his own era. His philology ranged over Greek, Latin and Hebrew, in which languages he had studied the principal philo-

sophical and theological works known to civilisation. His own theological works are a monument of erudition and learning. BARROW was very prolix, both as a speaker and a writer : He had a literary style of his own, which seemed to ignore punctuation and suchlike niceties of composition. The *Sermons*, which have been published in various forms, were of great length, and contain free references to the early works which BARROW had consulted in their preparation. All serve to indicate his complete grasp of classical literature.

In addition, and perhaps greatest and most remarkable of all, was his grasp of geometry, astronomy and mathematics. His geometrical lectures at Cambridge, which seem to have been delivered as Lucasian lectures, are examples of clear exposition for such an early period. (3) The mathematical lectures are, even to this day, a source of information : They form a clear and unrestricted statement of the philosophical principles which form the basis of mathematical speculation. In the *Lectiones* of BARROW we find much of interest and many items of great value in connexion with our development of the history of mathematical Time. BARROW was the first writer to attempt a rational discussion of Time from the mathematical standpoint. Being thorough in all things, he clearly appreciated the necessity of a firm foundation for mathematical principles. His treatment of mathematical Time brings out many points for speculation and development.

BARROW's *Lectiones Mathematicae*. The Mathematical lectures are twenty three in number, and appear to be the Lucasian lectures. In the English translation of the Reverend JOHN KIRKBY, London, 1734, the following notice appears at the end of Lect. XV : " The Lectures hitherto are writ as they were read publickly, the Order being no where interrupted : I now break the Series. For since I am neither obliged, nor able to exhibit all in fewer than ten Lectures at least, by Reason of the Greatness of the Labour and Want of Time; I have purposed to annex the three last to some few yet remaining." We do not wish to comment here

(3) A brief account of these lectures is given by J. M. CHILD, *The Geometrica Lectures of Isaac Barrow*. Mr. CHILD seems to think that they were not delivered in speech, but EDMUND STONES' translation (London 1735) says " read in the University of Cambridge."

XUM

upon the clarity of this statement. Prior to Lect. XVI we find the notice : " Mathematical Lectures Read in the University of Cambridge An. Dom. MDCLXVI." It seems reasonable, therefore, to suppose that the *Lectiones* were actually read to the University in 1664 and 1665, following the delivery of the Inaugural Oration as Lucasian professor at the beginning of the year 1664. We proceed to a critical examination of BARROW's temporal theory, as represented by the *Lectiones Mathematicae*.

Lect. IX, Pt. II. '*Of the Extension of Magnitude.*'

Here BARROW quotes numerous examples to illustrate the extension of all kinds of physical magnitude. He concludes that " a certain Duration intercedes between the first and last Instants of a Year, a Month, a Day or an Hour; according to which is the *Extension of Time*." Pursuing this conception, he arrives at the Hypothesis, " Ex. gr. Some mean Time may be understood between two Instants." This view evidently regards Time as a hypothetical medium which may be considered along with observable properties such as weight and measure, so far as extension is concerned.

Lect. X. '*Of Space and Impenetrability.*'

In discussing geometrical propositions of a rather involved character BARROW concludes : " I will only add this one observation more, that there is a great affinity and analogy between Space and Time. For as Space is to Magnitude, so does Time seem to be to Motion; so that Time is in some sort the Space of Motion. For when Time is called a Year, a Month or a Day, nothing seems to be signified but that such or so great a Motion is performed, or intercedes, or may be interposed in the meanwhile; ex. gr. one period of the Sun in the ecliptic; one return of the Moon to the Sun; or one revolution of the heavens (or the earth) about its axis. But this by the by, for Time itself now forbids us to treat more fully concerning Time."

This analogy of Time, Space and Motion also places Time in the category of measurable quantities; the measure being made by Motion. To attempt a *definition* of Time in this way would, however, lead to difficulties, since the concept of Motion involves Time, and any attempt to define Time in terms of Motion is hence circuitous. In the abstract sense we cannot use the concept

of Space as a measure of Time : There must be a *uniform* motion across or through the Space, and since the idea of uniform motion involves that of Time the definition is again circuitous. BARROW, however, does not attempt this : he is content to leave the matter in the form of an analogy, the only object of which is to assist the mind to a grasp of temporal relations : It is not intended as a model of reality.

Lect. XII. 'An Examination of the Objections brought by Proclus, etc.'

BARROW continues here " I say, the same way is Time conceived and denominated from the magnitude of the space run through by some body determinately movable, as the Sun or Moon, and it also borrows from them its terms, *Extension*, *Proportion*, and other affections, with respect to the magnitude of the same which it obtains..."

" Revolution of the same movable thing does always continue one and the same : Hence by means of it Motion and Time (their parts still beginning and ending in the same point of the periphery) are as it were united together and identified, and consequently are most perfectly congruous. Wherefore, the Year comes back upon itself, Months and Days return, Ages are renewed; the places and periods of Seasons are restored; and to use that trite saying of the vulgar, *Time itself seems to be a circle*, by reason of the circular and often repeated motion which determines it."

This passage seems to echo the Pythagorean idea of the periodicity of occurrences. According to EUDEMUS, ARISTOTLE's pupil, " the Pythagoreans believed that I shall again speak with you, that I shall hold in my hands the same staff, and that you will sit in the same place and listen to me... All things including Time will be identical " (4) (Book IV, 12). Indeed, BARROW goes on to quote actually from Book IV, 12 of the '*Physics*' as follows : " As one and the same Motion, says the philosopher (ARISTOTLE) may be performed again and again, so may one and the same Time, as a Year, the Spring or Autumn." Much of BARROW's argument seems to be based upon the *Physics* and *De Coelo* of ARISTOTLE.

(4) DIEL, *Commentary on Aristotle's Physics*. p. 732.

Lect. XVI. '*Of the Homogeneity and Heterogeneity of Quantities.*'

This lecture soon leads to an adverse criticism of HOBBS' ideas, as set forth in the *De corpore* and the *Dialogues*. BARROW says that "he feared not to compare *lines* and *times* together, as homogenous quantities obtaining a mutual proportion, though things of the most distant nature." He goes on to criticise HOBBS' analogy of Time and a line very thoroughly, and severely. He objects to the *identification* of Time with a line, " because they are not quantities after the same way, but have each a quantity of a different kind; or because it cannot be said without great absurdity that so much of Time is equal to so much of a line... the quantities of a Time and a line are of a different kind."

We shall find this analogy of Time with a line to occur frequently in subsequent writings. BARROW does not object to the analogy, but to extending it to an identity; which operation is, of course, at variance with logic.

BARROW's mathematical lectures abound with other examples of the idea of Time. Here we have mentioned only those which have some definite mathematical foundation or application. The problem of Time seems to have occupied much of BARROW's attention : we find considerable reference to it in his lectures on geometry, to which we now turn our attention.

BARROW's *Lectiones Geometricae.*

There is some difference of opinion among the very few historians who have studied BARROW's work as to whether these lectures were actually read. In the English translation from BARROW's Latin by EDMUND STONE (London 1735) it states on the title page that the lectures were " read in the University of Cambridge by ISAAC BARROW, D. D., Professor of Mathematics and Master of Trinity College, etc." and that they are " Translated from the Latin Edition, revised, corrected and amended by the late Sir ISAAC NEWTON."

Further, we find in the Preface that " This small Work, such as it is, you will upon perusal immediately perceive by many Tokens, not to have been designed to be made Publick, tho' I had often been importuned by several so to do... but that they are School Lectures, read by Duty, and sometimes spoken too hastily, that I might end my designed Talk within the Hour."

BARROW goes on to say that he has left the preparation of the work to the care of friends... " One of which (for I think my self bound to name them) is Mr. ISAAC NEWTON, my Collegue, a Man of great Learning and Sagacity, who revised my Copy and noted such Things as wanted Correction, and even gave me some of his own, which you will see here and there interspersed with mine, not without their due Commendations. The other is Mr. JOHN COLLINS (who may be deservedly called the *Mersennas* of our Nation, born to promote this Science, both with his own Labours, and those of others, who with much trouble took care of the Edition."

Lect. I.

This lecture contains some of BARROW's most important observations on Time. In considering Motion from a mathematical standpoint he examines the idea of the *quantity of motive force*, and says " But because the quantity of motive force cannot be known without Time, we must say something concerning its nature. Now pray tell me what Time is? You know the very trite saying of ST. AUSTIN, '*If no one asks me, I know; but if any person should require me to tell him, I cannot.*' But because mathematicians frequently make use of Time, they ought to have a distinct idea of the meaning of that word, otherwise they are quacks."

This expression of opinion is singularly applicable to the present day in connexion with mathematical physics. The notion of Time plays a role of ever-increasing importance in this department of knowledge. BARROW is undoubtedly right in insisting upon a grasp of the meaning and attributes of Time before we attempt to build a structure which may be regarded as a true reflection of reality.

The words of ST. AUGUSTINE which BARROW quotes are contained in Bk. XI, 17 of the *Confessions*, and read : "*Quid est tempus? Si nemo a me quaerat, scio, si quaerenti explicari velim, nescio.*" We shall presently observe a further similarity between the ideas of BARROW and AUGUSTINE on this subject.

BARROW is not satisfied with AUGUSTINE's confession : He goes on to give his own explanation of Time : For him, " Time (to speak abstractly) is the continuance of any thing in its own being."

XUM

He argues that some things continue longer in their beings than others; that some things enter into being and cease to be at the same time. " Time absolutely therefore is Quantity, as admitting in some manner the chief affections of Quantity, Equality, Inequality and Proportion; nor do I believe there is any one but allows that those things existed equal times, which rose and perished together; and that those things had unequal durations when the one was in being before the other had existence, and continue in its being after the other had ceased to be." We find a similarity between this view and the ideas of much more recent times in the *Traité de Mécanique* (5) of SIMÉON DENIS POISSON (1781-1840), wherein it is stated that " La notion des Temps égaux, et la mesure du temps ne sont fondées nécessairement sur aucune loi particulière de mouvement, et l'on peut, en conséquence, les supposer dans la définition du mouvement uniforme et de toute autre sorte de mouvements." In connexion with theoretical mechanics, and anent the question of using equal times as a means of measuring motion, WILLIAM WHEWELL (1794-1866), of Trinity College, Cambridge, has remarked : " Those intervals of time, in which there is no discoverable reason why they should be unequal, are supposed equal." (6)

BARROW proceeds to a consideration of the question whether Time existed before the world was created. He considers the world in the narrowest sense of the term, and concludes that Time existed before the world began " because it is possible that some thing might have existed long before the world was made." He does not consider the duration of existence of the matter from which the universe as we know it was evolved. By taking this restricted view, BARROW is at variance with ST. AUGUSTINE, who had paid attention to the same problem, and contended that : " *Non in tempore sed cum tempore finxit Deus mundum.*" AUGUSTINE, in opposition to BARROW, regards the world and Time as simultaneously created, and essential one to the other. (7) This point of difference, although of great interest, and opening up the whole vista of speculation as to the nature of Time, is not

(5) 2nd Edn. Tom. I, p. 205.
(6) Treatise on Mechanics. Art. 102 of 5th Edn., Cambridge, 1836.
(7) *De Civitate Dei.* Book XI, 5.

of mathematical importance. It does not matter to the mathematician whether there ever was a hypothetical and highly paradoxical ' period when Time was not.' He is only concerned with the hypothesis in so far as it enables him to obtain a conception of the nature of Time. (7*a*) To the mathematician, AUGUSTINE's hypothesis is hardly acceptable, since the creation of the universe as we know it can be proved, beyond any reasonable shade of doubt, to be the result of a purely physical phenomenon—the approach of a giant star to the proximity of the sun. It must presumably be allowed that Time existed prior to this event, for without Time we cannot conceive of the necessary motion which gave rise to the conditions. It seems, however, necessary for the purpose of AUGUSTINE's enquiry to consider the origin of the material from which our universe was evolved. Here the problem begins to become highly abstract, and speculative : it lies outside the scope of the mathematician, who is solely interested in the behaviour and attributes of physical phenomena, and not in their advent.

BARROW denies that Time implies Motion; " for whether things move on, or stand still; whether we sleep or wake, Time flows perpetually with an equal tenor." This is the conception which NEWTON held, and which gave rise to his definition of Time as " that which flows uniformly." BARROW goes on to observe that " the quantity of Time, so far as we can observe, depends upon the extension of Motion," and quotes, very aptly, from LUCRETIUS :

> *nec per se quenquam tempus sentire fatendum est*
> *Semotum ab rerum motu placidâque quiete.*

In support of his thesis he quotes again from ARISTOTLE (*Physics* 16, 4)—" When we wake we cannot perceive or tell how much Time has passed during our sleep," but he regards ARISTOTLE's dictum that ' because we do not perceive the thing, therefore there is no such thing' with disfavour, as a " false allusion, a deceitful

(7*a*) This subject is touched upon by WILLIAM WHEWELL in his *Philosophy of Discovery* 1860, p. 364 : " Whether we hold that there was a creation before which time and space did not exist—with the poet who says : Ere Time and Space *were* Time and Space were *not*—is not essential to our present enquiry. Certainly we cannot conceive such a state, and therefore cannot reason about it."

dream, that would cause us to join together two remote instants of Time."

Continuing his consideration of Time and Motion, BARROW refers to the measure of Time which is afforded by a uniformly moving body. We pause here to observe that uniformity of motion involves the notion of Time itself. He says that " of this kind is the motion of the stars, and particularly of the Sun and Moon, which observe a wonderful regularity one to the other in all things." For BARROW these bodies are deputed for the purpose of Time measurement in accordance with the divine will of the Creator (*Genesis* 1, 14). " Let there be Lights in the Firmament of Heaven, to divide the Day from the Night : and let them be for Signs, and for Seasons, and for Days and for Years." Then, says BARROW : " But you may ask, how we can know that the Sun moves with an equal Motion, that the Time of one day or year, for supposition sake, is exactly equal to that of another ? " His explanation involves inevitably the conception of ' equal times ' which he attempts to explain by reference to the sand or water Hour-glass, and he echoes the words of POISSON (5) and WHEWELL (6) which we have already quoted, when he says that " there is no manner of reason for us not to allow the times of every running out of the water or sand to be equal."

These conceptions lead BARROW to regard Time as a " uniformly extended quantum, all of whose parts correspond, either proportionately to the respective parts of an equal motion, or to the parts of spaces, moved through with an equal motion; it may therefore be very aptly represented to our minds by any magnitude alike in all its parts; and especially by the most simple ones, such as a straight or circular line; between which and Time there happens to be much likeness and Analogy."

From this idea springs a mathematical analogy which we shall find to be of the greatest importance in subsequent researches upon Time. The following quotation might be taken as the basis of the Mathematical Theory of Time :

" For as Time consists of parts altogether familiar, it is reasonable to consider it as a quantity endowed with one dimension only; for we imagine it to be made up, as it were, either of the simple addition of rising Moments, or of the continual flux of one Moment, and for that reason ascribe only length to it, and determine its quantity by the length of the line passed over : As a line, I say, is looked upon to be the trace of a point moving forward, being in some sort divisible by a point,

and may be divided by Motion one way, viz. as to length; so Time may be conceived as the trace of a Moment continually flowing, having some kind of divisibility from an Instant, and from a successive flux, inasmuch as it can be divided some how or other. And like as the quantity of a line consists of but one length following the Motion, so the quantity of Time pursues but one succession, stretched out, as it were, in length, which the length of the space moved over shows and determines. We therefore shall always express Time by a right line."

This identification of Time with a line is the first step towards a mathematical theory, and may be regarded as the first simple generalisation which allows of a grasp of the mathematical significance of Time. The analogy is quite satisfactory for ordinary physics: it only becomes inadequate in modern mathematical physics, using the conception of atomism framed in space-time co-ordinates.

Recent advances in observational astronomy would also seem to indicate that the conception of an even-flowing uniform Time, representable by a mathematical line, is untenable as a system of reference for stellar phenomena. It seems not unlikely that the problem of the expanding universe with which astronomers are now confronted may resolve itself into some such readjustment of our scales of reference as an abandonment of this simple view of mathematical Time.

It should, however, be observed that the conception is in accordance with the speculations of more than one philosopher of repute. In his *Dissertatio pro loco professionis*, the "De Mundi Sensibilis atque Intelligibilis Forma et Principiis," printed in 1770, KANT makes a reference to the representation of time "by a straight line extended to infinity," (8) while SCHOPENHAUER issues the dictum that "Time can be perceived *a priori*, although only in the form of a line" as one of the twenty-eight *praedicabilia de tempore* in his "Die Welt als Wille und Vorstellung."

In extending his analogy, BARROW touches immediately upon a further idea which has a counterpart in modern physics. Just as a line may be regarded as an aggregate of mathematical points, so it is the same thing for BARROW if "Time be supposed to consist of Instants, or of innumerable small Times." Some of the latest researches in mathematical physics seem to show that Time actually consists, in so far as physical phenomena are

(8) § 14 (5), *Nota*.

concerned, of ' atoms of Time ' having values of the order of 4.5×10^{-24} seconds, that is to say, four and a half million million million millionths of a second : quite small enough for the purpose of illustrating BARROW's theorem.

BARROW concludes the first lecture with descriptions and diagrams of a simple kind, relating Time with Space and Motion for bodies travelling with either uniform or accelerated motion. The remaining lectures are purely geometrical or mathematical, and the conception of Time enters here and there only as a simple concept.

As we proceed to the history of more modern times, the scope of BARROW's observations on Time, as represented by his mathematical and geometrical lectures, will become more apparent. In many parts of this work BARROW appears very much in advance of contemporary thought. This is, no doubt, largely on account of his indifference to established opinion or the work of great minds. He was entirely original in all his undertakings.

In this connection, it is of interest to note that the *Lectiones Geometricae* contain the first germs of the conception of the differential calculus : perhaps rather more than this; the actual calculus in an unfinished form : Such was the genius of ISAAC BARROW. We can think of no better termination for this brief account of one small part of his work than the words on his statue in the ante-chapel of Trinity College :

vir suo tempori
pietatis probitatis Fidei eruditionis
modestiae suavitatis exemplum...

III. — *The Contemporaries and Followers of Sir Isaac Newton*

NEWTON's ideas concerning Time, as expressed in his various published writings, rarely appear in a connexion which might be regarded as purely mathematical : They are mostly given in the form of laws attaching to physics, or in a mathematical connection where they do not form an essential or even highly important part of the subject.

For our present purpose, the most interesting statement of NEWTON concerning Time is contained in his *Philosophiae Naturalis*

Principia Mathematica, and forms the first of his Definitions of Time, Space and Motion :

" Absolute true, mathematical time of itself and from its nature without relation to anything external flows equally; and its other name is duration."

The first edition of the *Principia* appeared in 1687, so that this view is considerably anterior to those of BARROW which we have just outlined. The similarity between the views of these two mathematicians is very evident, and it is not unlikely that NEWTON was influenced to some extent by his old tutor. We have already observed that NEWTON was quite familiar with the substance of BARROW's lectures : in fact it appears that his discovery of the differential calculus was in no small measure due to his acquaintance with BARROW's writings.

It is interesting to observe that in the formulation of the definition of Time NEWTON makes the important reservation : " *without relation to anything external.*" The literal meaning of this is somewhat difficult to grasp, but it is probable that he had in mind the confusing notions of Time which had arisen through unwarranted speculations and analogies such as were then so popular. The destruction of these confused ideas, and the establishment of mechanics and physics on a firm logical basis, devoid of all metaphysical superfluities, was part of the function of the *Principia*. Until the advent of what we may term the modern period of mathematical physics, NEWTON's laws enjoyed universal, even if not undisputed, acceptance : For more than two centuries they formed the basis of all mathematical enquiry into natural phenomena.

For NEWTON, Time also presented a metaphysical conception, which is clearly outlined in the scholium to the third book of the *Principia*, where he states that God is not eternity and infinity, but eternal and infinite; " He is not duration and space, but He continues and is present. He continues for ever and is present everywhere, and by continuing to be always and everywhere, He constitutes duration and space." NEWTON regards Time itself, as distinct from mathematical Time, together with Space as forming the *sensorium Dei*. In the *Scholium Generale* of the *Principia* this notion is clearly stated with reference to our own ideas : " Partes dantur successivae in duratione, coexistentes in

spatio, neutrae in persona hominis seu principio ejus cogitante; et multo minus in substantia cogitante Dei."

These views were soon attacked by the philosophers : and chiefly by Bishop BERKELEY, whose views, as represented by the *Principles of Human Knowledge* (1710) and the *De Motu* (1721) we have already mentioned. The problem of Time was also attacked by the philosopher DAVID HUME, who regarded the relations of Time and Space as among the most universal and comprehensive, and as the sources of an infinite number of comparisons. (9) For HUME, Time consists of indivisible moments, but he admits that arguments to this effect introduce difficulties to which it is impossible to provide any satisfactory answer.

The nature of Time and Space was one of the many problems studied by the great mathematician, LEONHARD EULER (1707-1783), in connexion with theoretical mechanics. His analysis of the problem is contained in a memoir entitled *Réflexions sur l'espace et le temps* in the Memoirs of the Berlin Academy, 1748. This memoir is primarily concerned with the problem of absolute Space, which had taken on a most complex character as the result of philosophical speculation. EULER sought to show that the concept of absolute Space is implicated in the fundamental laws of Mechanics. In this connexion he regards the law of inertia as fundamental as a criterion of the necessity for considering the character of absolute Space and Time. As CASSIRER puts it : " What is the essence of space and time is not important; but what is important is whether they are required for the statement of the law of inertia." (10) If this law can be completely specified only by the introduction of the conception of absolute Space and Time, then we may reasonably conclude that these conceptions are necessary. By this argument EULER sought to remove the obscurities from the many conceptions of space and time which then existed, and to give further strength to the foundations of mechanics, which must form the basis of all mathematical physics.

Valuable observations on Time and Space from a mathematical point of view were made by COLIN MACLAURIN (1698-1746),

(9) *A Treatise of Human Nature*. 1739, Bk. 2. Art. 3.
(10) *Das Erkenntnisproblem*, Vol. II, p. 476.

professor of mathematics in the marischal college of Aberdeen at the age of nineteen, and successor to JAMES GREGORY—of whom we have already spoken—as professor of mathematics in the University of Edinburgh in 1725, at the age of twenty-seven. His views on Space and Time are given in *An Account of Sir Isaac Newton's Philosophical Discoveries*, (11) published from MACLAURIN's manuscript papers after his death by PATRICK MURDOCH. This work is divided into four books, as follows :

Book I. Of the method of proceeding in natural philosophy, and the various systems of philosophers.
Book II. Of the theory of motion, or rational mechanics.
Book III. Gravity demonstrated by analysis.
Book IV. The effects of the general power of gravity deduced synthetically.

Chapter I of the second book treats " of space, time, matter and motion " : " From the succession of our own ideas, and from the successive variations of external objects in the course of nature, we easily acquire the ideas of *duration* and *time*, and of their measures." This notion compares with the views of LEIBNIZ and other philosophers, but does not take us very far mathematically. MACLAURIN's next observation is, however, of direct mathematical interest : " We conceive true or absolute time, to flow uniformly in an unchangeable course, which alone serves to measure with exactness the changes of all other things... Time may be conceived to be divided into successive parts that may be less and less without end; tho' with respect to any one particular being, there may be a least sensible time, as well as a *minimum sensible* in other magnitudes." This may be regarded as a compound of BARROW's idea of Time as composed of indefinitely small times and NEWTON's idea of Time as that which flows uniformly. In taking these views, MACLAURIN adopts the purely mathematical viewpoint of Time as a linear, divisible continuum of infinite extent. These views are necessary for the establishment of the fundamentals of mechanics, to which MACLAURIN proceeds to apply them. Book II, Ch. I, Art. 11 : " Space and Time serve to measure each other, reciprocally, by motion : Time is

(11) 1st Ed. 1748, 2nd Ed. 1750, 3rd Ed. 1775. We are using the 2nd Edition.

in a perpetual flux and perishing; but a representation of it is preserved in the space described by the motion." The fundamental ideas of uniform, accelerated, and decelerated motion, are then presented with the aid of a rectangular space-time diagram, which is exactly analogous to the one used by BARROW for the same purpose.

Book IV, ch. IX, the last, is essentially devoted to clearing up a point of NEWTON's philosophy which had been misunderstood by contemporary philosophers, i.e., the omnipresence of the Deity. MACLAURIN accordingly heads this chapter " Of the Supreme Author and Governor of the universe, the True and Living God," and commences with a statement which clearly defines the attitude of many scientists and mathematicians, even to this day, towards the problem of the universe :

" ARISTOTLE concludes his treatise *de mundo* with observing that " to treat of the world without saying anything of its Author would be impious " as there is nothing we meet with more frequently and constantly in nature than the traces of an All governing Deity. And the philosopher who overlooks these, contenting himself with the appearances of the material universe only, and the mechanical laws of motion, neglects what is most excellent; and prefers what is imperfect to what is supremely perfect, finitude to infinity, what is narrow and weak to what is unlimited and almighty, and what is perishing to what endures for ever."

There can be no denying that in the consideration of fundamental problems, such as Time and Space, we are led by the very abstruseness of the subject to place the origin of it with an Almighty Author. Such considerations lead directly to the principles of religion, which must of necessity step in when our speculations on the nature of the universe and its setting of space and time tend to exceed the bounds of human intellect. MACLAURIN's view is essentially that held by modern men of science : There is something beyond all our science and mathematics : These serve only to indicate the nature of the physical world, and we must turn to other methods if we would discover the nature of its system.

We have already remarked upon the conception of Time underlying the Newtonian method of fluxions. In the Introduction to his *Quadruture of Curves* of 1704 he says : " I consider mathe-

matical quantities in this place not as consisting of very small parts; but as described by a continued motion." We have seen that this method of conceiving such quantities was a reversion of his ideas as presented by the *Principia* of 1687, and necessary in order to free his *methodus fluxionum* from the objections of philosophers and metaphysicians. In the *Quadratura* NEWTON therefore regards Time as being generated by a 'continual flux.' Whichever view is adopted, we are led to regard Time as having a discrete nature. The doctrine of infinite divisibility reduces to very little other than the mathematical principle involved in considering Time as the trace of an instant; both views involve an abstraction of a mathematical nature which enables us to conceive of Time not as a continuous entity, but as a generated continuum, which may be resolved for the purpose of analysis into a simple generating function, the atom of Time.

The concept of Time is introduced in Art. 17, where NEWTON states the principle of Fluxions as follows: "For let O be a very small quantity, and let $O\dot{z}$, $O\dot{y}$, $O\dot{x}$ be the moments, i.e. the momentaneous synchronal increments of the quantities z, y, x, then after a moment of Time, being increased by their increments $O\dot{z}$, $O\dot{y}$, $O\dot{x}$, these quantities shall become $z + O\dot{z}$, $y + O\dot{y}$, $x + O\dot{x}$: which being wrote in the first equation for z, y and x give..." In this demonstration, $\dot{z}$, $\dot{y}$, $\dot{x}$ are the "Fluxions or Celerities" of the variables x, y, z respectively. NEWTON identifies his increment of each variable during the "moment of Time" with zero in order to conform with the previously conceived notion of Time as generated by the flux of an instant.

The *Quadratura* was translated by JOHN STEWART, professor of mathematics at Aberdeen, and published along with a lengthy commentary in 1745. It is interesting to note that STEWART himself observed the necessity for a clear specification of the underlying idea of Time, for he gives the following addendum: "The Reader may be pleased to observe that by the Phrase *Instant of Time* made use of in the following Work, is not meant any Portion of Time, or Part of Duration, how small soever, which must be divisible into Parts, like all other kinds of Quantity; but an Instant of Time must be conceived as having no Parts, and to be with respect to any Portion of Time or Duration, what a Point is with respect to a line in Geometry." Thus we observe

XUM

that STEWART's conception of Time agrees with and strengthens the ideas of BARROW, NEWTON and MACLAURIN.

The observations on Space and Deity contained in NEWTON's *Principia* and *Optics* were very strongly defended by W. EMERSON in *A Short Comment on Sir I. Newton's Principia*, published in 1770. EMERSON calls these views " the best metaphysical notions of God that can be met with any where," and proceeds severely to criticise the objections of LEIBNIZ to which we have already referred. The following quotation from EMERSON's defence of the *Optics* shows clearly his attitude towards NEWTON's philosophy, and also, incidentally, the style of scientific discussion which was popular at this time. " This Gentleman (EMERSON is alluding to LEIBNIZ) calls God a *supramundane intelligence*, which is only an unintelligible term to quack with. For certainly he exists *in* the world, but after what manner is a secret to us. If God have any existence, he exists *in* space; to say that he exists *out of* space is to say that he does not exist at all, because space is everywhere. So does he exist *in* time; for to exist *out of* time, or in no time, is not to exist. He exists then in all space and in all time, that is *always* and *every where*."

In his Inaugural Dissertation of 1770 *De Mundi Sensibilis atque Intelligibilis Forma et Principiis* IMMANUEL KANT arrived at significant conclusions with regard to both metaphysical and mathematical Time. He regards Time as a continuous quantum (§ 14, 4), of which any part is a time. Moments are not parts of Time; They are limits *(termini)* between which there is a stretch of Time. His metaphysical law of continuity is that opposite states succeed one another only through an intermediate series of different states. This conception agrees very closely with the doctrine of infinite divisibility and generation *per fluxiones* of the mathematicians. For KANT, Time is not objective and real, but a subjunctive condition or pure intuition, necessary on account of the nature of the human mind in the co-ordinating of all impressions according to a definite law : " condicio per naturam mentis humanae necessaria quaelibet sensibilia certa lege sibi coordinandi " (§ 14, 5). In a note concerning the definition of Time, KANT makes an observation having direct connexion with the ideas of BARROW : " For simultaneous things are joined in the same moment of Time just as successive things in different moments.

Thus, though Time possesses only one dimension, yet the ubiquity of Time (to borrow NEWTON's phrase) owing to which all things conceivable by sense are at some time, adds to the quantum of actuals a second dimension, so far as they hang, so to speak, from the same point of Time. For if you represent Time by a straight line extended to infinity, and all simultaneous things at any point of Time by lines drawn perpendicular to it, the plane thus generated will represent the phenomenal world, both as to its substance and as to its accidents." (§ 14, 5 *nota*). This view may be regarded as connecting the mathematical conceptions of BARROW, and, to a lesser extent, NEWTON, with comparatively modern ideas to which we shall presently refer.

KANT regards it as absurd to attempt a criticism of the view he establishes, which is based upon the first postulates of pure Time. These follow from laws which are essentially primitive and original : than which nothing more primary or original can be found (§ 15, 6).

In the *Kritik der reinen Vernuft*, first published in 1781, we find many ideas which contrast with those of the *Dissertatio* of 1770. The *Kritik* contains some of the most valuable of KANT's speculations on Time from the mathematical viewpoint. Here KANT considers that in Time alone rests the possibility of real phenomena. Relations or axioms of Time depend upon this *a priori* necessity : Time has only one dimension and different times are successive (p. 31, second section of " Trans. Aesth."). Different times are parts only of one Time (p. 32 *ibid.*). In this connexion the following statement is significant : " Those... who maintain the absolute reality of Space and Time, whether as subsisting or only as inherent, must come into conflict with the principles of experience itself. For if they admit Space and Time as subsisting (which is generally the view of mathematical students of nature) they have to admit two eternal infinite and self-subsisting nonentities (Space and Time), which exist without their being anything real, only in order to comprehend all that is real." (pp. 38 *et seqq.*, *ibid.*). We may here pause to remark that the mathematical view to which KANT refers appears, in fact, to be implied in modern mathematical physics. There is, at least, a persistent tendency in this department of knowledge to treat Time as having an objective existence.

The connexion between arithmetic and Time is clearly recognised by KANT, who states in a letter to SCHULTZ : (12) " Time, as you justly remark, has no influence upon the properties of numbers (as pure determinations of quantity), such as it may have upon the nature of those changes (of quantity) which are possible only in connexion with a specific property of inner sense and its form (Time). The science of number, notwithstanding the succession which every construction of quantity demands, is a pure intellectual synthesis which we represent to ourselves, in thought. But, so far as quanta are to be numerically determined, they must be given to us in such a way that we can apprehend their intuition in successive order, and such that their apprehension can be subject to Time."

Views differing from those of KANT were evinced by SCHOPENHAUER, in his *Die Welt als Wille und Vorstellung*, to which we have already made reference. He considers that " whoever has recognised the form of the principle of sufficient reason, which appears in pure Time as such and on which all counting and arithmetical calculations rest, has completely mastered the nature of Time." We shall find that this view coincides with purely mathematical work of a considerably later date. Among the twenty-eight *praedicabilia de tempore* in the same treatise, the following are of interest from the mathematical viewpoint.

4. Time has three divisions : the past, the present and the future, which constitute two directions, and a centre of difference.
8. By reason of Time we count.
11. Time can be perceived *a priori*, although only in the form of a line.
27. Time makes arithmetic possible.
28. The simple element in arithmetic is unity.

SCHOPENHAUER's treatise may be regarded as a criticism of KANT's views. He agrees with KANT that the concept of Time is essential to experience, and regards the operation of counting as resting on the perception of Time, in the same manner that geometry rests on the perception of Space. Since counting depends upon repetition, which in turn involves the concept of succession and hence of pure Time, counting is only possible by means of Time. SCHOPENHAUER therefore concludes that

(12) *Vide* N. K. SMITH, *A Commentary to* KANT's *Critique of Pure Reason*, p. 130.

" If Arithmetic had not this pure intuition or perception of Time at its foundation it would be no science *a priori*, and therefore its propositions would not have infallible certainty."

IV. — *The Nineteenth Century; Mathematical Theories of M. Buée, and Sir William Rowan Hamilton*

What is perhaps the very first purely mathematical theory of Time is contained in a *Mémoire sur les Quantités imaginaires* by M. BUÉE (1748-1826). This paper represents an explanation of the mathematical significance attaching to imaginary and complex quantities. It was communicated to the Royal Society of London by WILLIAM MORGAN, and published in Part I of the 'Philosophical Transactions' for 1806. As a contribution to mathematics the paper is of great interest on account of its unorthodox method. (13) The theory of Time is developed in Arts. 22 to 25, of which the former, upon which the subsequent theory is based, contains the following unrigorous statement: " $\sqrt{-1}$ indique une *qualité moyenne* entre deux qualités opposées dont l'une est exprimée par $+$ et l'autre par $-$." In Art. 23 BUÉE concludes that if a certain period of Time past be denoted by $-t$, and an equal period into the future be $+t$, then the first half of the present period is $\frac{1}{2}(-t\sqrt{-1})$ and the second half, $\frac{1}{2}(+t\sqrt{-1})$, from whence the present period is expressed by $\frac{1}{2}(-t\sqrt{-1}) + \frac{1}{2}(+t\sqrt{-1}) = 0$. Anent this demonstration he remarks, " Or O (qui, comme on le verra bientôt, a deux significations) est la veritable expression du présent." This reduction of a period of Time to zero is explained in Art. 25 as expressing the sentiments of a man who, after a sojourn, returned to the point from which he had started and said: " I am not more advanced after travelling so far than if I had not moved " because, says BUÉE, " *le temps* est pour l'esprit ce que *l'espace* est pour le corps."

It may be noted that BUÉE adopts the linear temporal continuum, as represented by a straight line in agreement with BARROW, NEWTON and the others, without any hesitation. By applying

13) See the author's paper *History of the Theory of Imaginary and Complex Quantities* in the 'Mathematical Gazette,' 14, October 1929, p. 538.

his theorem that the square root of minus one denotes intermediacy between a positive and a negative quantity or direction he is able to identify an instant of Time, i.e. the Present, with mathematical nonentity, zero. This is in agreement with the mathematical view of Time as being a continuum divisible theoretically *in infinitum*. Thus BUÉE's results are in accordance with the consensus of mathematical opinion.

The reception of BUÉE's paper at the hands of contemporary mathematicians was varied. An extensive and deprecatory review, which has been attributed to GEORGE PEACOCK (1791-1858), Lowndean professor of astronomy and geometry at Cambridge, and later Dean of Ely, appeared in the 'Edinburgh Review' for 1810. (14) This review contains no reference whatever to the temporal theory given in Arts. 22 to 25 of the paper, but strongly criticises the metaphysical tendency of the whole exposition. In his *Algebra* (15) of 1830 PEACOCK quotes BUÉE's memoir as containing "some original views on the use of the signs of Algebra, though presented in a very vague and unscientific form." This opinion does not seem to have been shared by DUNCAN FARQUHARSON GREGORY (1813-1844), a Fellow of Trinity College, as also was PEACOCK, who wrote on symbolical algebra, logarithms with complex bases, and the calculus. In his *Examples of the Differential and Integral Calculus* (16) GREGORY quotes BUÉE's paper as an authority for information on the general interpretation of formulae in analytical geometry.

The Hamiltonian Theory of Pure Time. — The theory which now occupies our attention was presented in a paper entitled *Theory of Conjugate Functions, or Algebraic Couples; with a Preliminary and Elementary Essay on Algebra as the Science of Pure Time*, which was read before the Royal Irish Academy on November 4th, 1833, and June 1st, 1835, by Sir WILLIAM ROWAN HAMILTON (1805-1865), professor of Astronomy in the University of Dublin and Astronomer Royal of Ireland. This paper may be regarded as one of the most important published contributions to the mathematical theory of Time: No reference to spatial conceptions is

(14) Vol. 12, pp. 306-318.
(15) P. xxvii of Preface.
(16) Cambridge, 1841. p. 174.

made;the development is purely synthetic, and no appeal is made to physical principles.

In the words of ALEXANDER MACFARLANE (1851-1913) of the University of Edinburgh, later of Texas and Lehigh, who did much to promote the study of HAMILTON's Quaternions, HAMILTON's memoir has " proved a conundrum to the mathematical world." (17) It should be remarked that the speculations underlying this theory are in places allied to the fundamentals of Quaternions, which subject was perfected by HAMILTON some six years later.

The general scepticism which met HAMILTON's theory of Pure Time is clearly reflected in the following passage from ARTHUR CAYLEY's presidential address to the British Association in 1883 on the " Progress of Pure Mathematics " : " Hamilton uses the term algebra in a very wide sense, but whatever else he includes under it, he includes all that in contradistinction to the Differential Calculus would be called algebra. Using the word in this restricted sense, I cannot myself recognise the connection of algebra with the notion of time; granting that the notion of continuous progression presents itself and is of importance, I do not see that it is in any wise the fundamental notion of the science. And still less can I appreciate the manner in which the author connects with the notion of time his algebraic couple or imaginary magnitude, $a + b\sqrt{-1}$." We return later to a discussion of the points here raised by CAYLEY, but in passing it may be remarked that HAMILTON considers the notion of Time to be connected with existing algebra : he does not go so far as to say that it is the ***fundamental notion*** of that science.

It is of interest to note that ARTHUR CAYLEY (1821-1895), first Sadlerian professor of pure mathematics at Cambridge, had attended HAMILTON's lectures on Quaternions while a student in Dublin. Mathematicians of the time were very divided in their views on Quaternions, and CAYLEY belonged to the school which thought but little of them.

In the General Introductory Remarks to his paper HAMILTON

(17) In a lecture on HAMILTON delivered at Lehigh University in 1901. See MACFARLANE *Ten British Mathematicians*, New York, 1916. MACFARLANE was president of the International Association for Promoting the Study of Quaternions and Allied Systems of Mathematics.

XUM

expresses the view that the intuition of Time is a rudiment from which may be developed, by valid reasonings from its own intuitive principles, an independent science of Algebra; a science not less removed than Geometry from the principles of *a priori* contemplation. This view involves three fundamental concepts :

(1) That the notion of Time is connected with existing algebra.
(2) That the notion or intuition of Time may be developed into an independent pure science.
(3) That the science of Pure Time thus developed is co-extensive and identical with Algebra, so far as algebra is a science.

The foundations of these concepts, wherein lies the whole basis of HAMILTON's theory, are as follows :

I. That the notion of time is connected with existing algebra may be induced from historical considerations, which show that many important additions to the science were made either expressly through the notion of Time, or through the related notion of Continuous Progression. Algebraical science may be considered in relation to flowing quantities, in contradistinction to the fixed constructions forming the basis of Geometry. Whereas the Euclidean definition of a tangent is purely geometrical, the Newtonian definition rests upon the concept of a nascent or gradually generated figure, and hence relies upon the notion of fluxion and of Time.

II. That the notion of Time may be developed into an independent pure Science is a deduction from the *a priori* principles of Time, which admit of a clearly defined system : If we consider an abstract point of Time, it is an *a priori* certainty that it either coincides with or precedes or follows any specified point of Time.

III. That the science of Pure Time is co-extensive and identical with existing algebra is a conclusion involving the foregoing concepts, which it is the object of HAMILTON's enquiry to establish.

We have referred to the analogy between Time and Number recognised by certain of the philosophers. In the abstract scheme which HAMILTON develops we are led to represent times by means of pure numbers, and intervals by means of the difference of two numbers, representing respectively the beginning and end of the interval.

In the abstract scheme any particular moment of Time may be represented by a number specifying the order of the moment

in respect to the chosen representative number continuum. Thus any particular pair of moments may be specified and their order of priority distinguished by means of two numbers bearing to one another the same relation in the number-continuum as exists between the moments in the temporal sense. If these two numbers coincide, the identity between the two corresponding moments is established, and only a single moment of Time is considered. If the numbers differ, then two different moments of Time are indicated; their temporal relation being exhibited by the arithmetical order of the numbers in the number-continuum.

In HAMILTON's memoir, if any moment of Time be denoted by A, then any other moment may be denoted by B, and coincidence or difference between the moments are respectively indicated by $B = A$, and $B \neq A$.

It is evident that the latter expression of inequality may be due either to subsequence or precedence of one of the moments. If B is subsequent to A, then $B \neq A$, because $B > A$ and, conversely, if A is subsequent to B, then $B \neq A$ because $A > B$. In general, therefore,

$$\text{if } B = A, \text{ then } A = B$$
$$\text{if } B \neq A, \text{ then } A \neq B$$
$$\text{if } B > A, \text{ then } A < B$$
$$\text{if } B < A, \text{ then } A > B$$

HAMILTON continues with the comparison of two pairs of moments, with respect to their analogy or non-analogy.

If we consider any two other moments, C and D, it is *a priori* necessary that they either coincide with or differ from A and B. If the relations $C = A$ and $D = B$ are both satisfied, then C and D are the same pair of moments as A and B. It is manifest that complete identity of both pairs of moments is not the sole criterion of equivalence of their relations, for it is possible that the same relations exist between two different pairs of moments; thus the two pairs, A, B and C,D may be analogous, even if not coincident with each other. Such analogy may be expressed as follows :

$$D - C = B - A$$
$$\text{or } B - A = D - C$$

These expressions are equally applicable to coincident or different pairs.

It is further evident that in two analogous pairs of moments, the relation of D to B is exactly that of C to A, as is also the case with coincident pairs of moments. It follows that if the pairs A, B and C, D be analogous, then the pairs A,C and D,B are also analogous, since

$$\text{if } D - C = B - A, \text{ then } D - B = C - A.$$

HAMILTON calls this expression an *alternation* of the original analogy.

On considering the original pairs in inverted order, B,A and D,C, we observe the further relation :

$$\text{if } D - C = B - A, \text{ then } C - D = A - B.$$

which HAMILTON calls an *inversion* of the original analogy.

From the last two relations we finally obtain :

$$\text{if } D - C = B - A, \text{ then } B - D = A - C$$

and, in general :

$$\begin{aligned} D - C &= B - A, & B - A &= D - C \\ D - B &= C - A, & C - A &= D - B \\ C - D &= A - B, & A - B &= C - D \\ B - D &= A - C, & A - C &= B - D \end{aligned}$$

HAMILTON extends these preliminaries to the idea of *continued analogies*, or equidistant series of moments; to submultiples and fractions of any given step in the progression of Time, and to mathematical operations with these quantities which lead directly to his Algebra of Pure Time. The first section of the paper, containing these developments, occupies ninety-three quarto pages.

In the second section, on the Theory of Conjugate Functions, occupying a further twenty-nine pages, HAMILTON considers the conception of moment-couples, which are defined as being of the form (A_1, A_2), where A_1 is a *primary moment* and A_2 a *secondary moment*, irrespective of whether A_2 follows, precedes or coincides with the primary moment. From this conception HAMILTON develops the algebraical theory of number-couples, which leads ultimately to the appearance of the imaginary $\sqrt{-1}$, which may be regarded as an indication of the generality of the theory.

It is a strange fact that HAMILTON's memoir, important though it is, remains to this day practically unknown to mathematicians. Among the few references to the paper which exist, the following statement of CASSIRER with reference to the Kantian philosophy

of Time is of interest : " It is easily seen that KANT is only concerned with the ' transcendental ' determination of the concepts of Time, according to which it appears as the type of an ordered sequence. WILLIAM ROWAN HAMILTON, who adopts KANT's doctrine, has defined algebra as the " Science of Pure Time, or order in progression." (18)

(to be continued)

(Bedford) G. WINDRED

(18) Kant und die moderne Mathematik in Kant-Studien, 12 (1907), p. 34. *Vide etiam* N. K. SMITH, " A Commentary to Kant's ' Critique of Pure Reason,' " 1918, p. 128, *et seqq*, and the author's paper " A History of the Theory of Imaginary and Complex Quantities." *Cit. ante*, pp. 539-541.

The Origins of the Geometric Principle of Inversion

1. — Introduction

It is said that history repeats itself. It can with equal truth be remarked that not infrequently history is made simultaneously in several far removed places. In witness of this one need only recall the invention of the calculus by the Englishman Newton and the German Leibnitz, or the discovery of non-Euclidean geometry by the Hungarian Bolyai and the Russian Lobachevsky, two illustrious examples in the field of mathematics. It does not appear that either of these discoveries sprang fullgrown into being, but rather each was the natural step in a sequence of events which had been moving along slowly for many years. And at the proper moment in this chain of events a genius appeared and made the difficult and important step. It is interesting to note that the fundamentals of the infinitesimal calculus are found in the works of the geometer Barrow, Newton's teacher, but so hidden by the geometrical language which Barrow uses that only recently has this fact been brought to light. (1) Whether Newton fully appreciated the significance of his tutor's work, we can only guess; but the fact remains that Barrow was thinking along the same lines that ultimately led Newton to his great discovery. On the other hand the attempts to prove Euclid's parallel-postulate led Saccheri to the very threshold of the discovery of non-Euclidean geometry almost a century before Bolyai published his work; but he failed to go further.

So it is with our more humble subject of inversion. When one seeks to find to whom we are indebted for the invention

(1) *The Geometrical Lectures of Isaac Barrow*, by J. M. Child, Chicago 1916.

of this fruitful method of geometry he is confronted only by meagre footnotes and confusing references in the literature. For example, CHASLES (2) mentions QUETELET and BELLAVITIS as the first to make use of this method of transformation, but we feel his claim to authority to be somewhat lessened when he admits in another place that he does not know what the Germans might have done, for he is not familiar with their language. (3) Then BÜTZBERGER, in setting forth STEINER's claims to the honor of discovery, neglects to mention what claim, if any, STEINER's foreign contemporaries DANDELIN and QUETELET might have; although he is very careful to point out that those whom he does mention were anticipated by STEINER by some ten or twenty years. It is our purpose then to set forth the facts as a study of the sources reveals them, hoping thereby to straighten out some of this confusion. In doing so we shall follow as closely as possible a chronological order in the presentation of each individual's work.

But before presenting our various exhibits a few words concerning inversive geometry might be appropriate here if for no other reason than to emphasize the fundamental differences between projective and inversive terminology. Given a center of inversion O and a measure k^2 any two points of the plane, P and P′, which are collinear with O and lie on the same side of O, and such that $OP.OP' = k^2$ are inverse points with regard to the center O and measure k^2 (or with regard to the circle having center O and radius k). The infinite region of the inversive plane is a single point which is the inverse of the center of inversion O. The simplest curve is a circle; and straight lines, being circles of infinite radii, are equivalent to circles. The next class of curves consists of biquadratics which include, among others, those curves projectively designated as conics, circular cubics, and bicircular quartics. For example, an ellipse, hyperbola or parabola is a biquadratic having at infinity an isolated doublepoint, a real doublepoint or a cusp respectively; and a circular cubic is a biquadratic passing through the infinite point of the plane. A biquadratic has four foci; two coincident foci produce

(2) *Rapport sur les Progrès de la Géométrie*, Paris, 1870, pp. 140, 351.
(3) *Aperçu Historique des Méthodes en Géométrie*, Paris 1889, p. 215.

XUM

a doublepoint and three coincident foci a cusp; a biquadratic with two doublepoints is degenerate and consists of two circles.

2. — DANDELIN (1794-1847)

The first session of the Brussels Academy was held November 20, 1816. In the second volume of the *Nouveaux Mémoires* of that Academy we find a note to the effect that QUETELET (who was elected to membership in 1820) had presented a memoir "*sur quelques nouvelles propriétés de la focale et sur autres courbes*" which brought to a conclusion certain earlier researches concerning this same *focale*, a curve which, he discovered, had much in common with other known curves. This article, however, was not printed, QUETELET having withdrawn it upon learning that his friend DANDELIN was investigating the same subject. DANDELIN's "*Mémoire sur quelques propriétés remarquables de la focale parabolique*" (4), read at the session of April 1, 1822, is noteworthy in that it contains the first statement of his investigations concerning the focal spheres of a cone : a plane cuts a right circular cone in a conic section and the two spheres inscribed in this cone and touching the plane touch it at the foci of the conic section. Now as the plane of section moves always passing through a fixed point A on the cone and perpendicular to the plane determined by A and the axis of the cone, the foci of the conic sections so generated trace the *focale* of QUETELET. DANDELIN then proceeds to give various methods of generating the *focale* and shows (1) that it is the envelope of a system of circles whose centers lie on a parabola and which pass through a fixed point B on the directrix of the parabola and (2) that a hexagon whose sides are arcs of circles (each passing through the fixed point B, which is the node of the *focale*) inscribed in the *focale* gives a theorem analogous to PASCAL's Theorem for conics. By a stereographic projection a circle projects into a circle and hence by (1) above the *focale* projects into a system of circles on the sphere which DANDELIN calls a *sphéri-focale*. A second stereographic

(4) *Nouveaux Mémoires de l'Académie Royale des Sciences et Belles-Lettres de Bruxelles*, t. II (1822), pp. 171-202.

projection from the sphere onto a second plane where the center of projection is the node of the *sphéri-focale* gives as a projection a conic, for by (2) above, the inscribed hexagon whose sides are circular arcs projects into an inscribed hexagon whose sides are straight lines and opposite sides of this inscribed hexagon meet in three collinear points. The conic is an hyperbola whose infinite point (5) is the projection of the node of the *sphéri-focale*.

Such, in brief, is DANDELIN's method of approach. But for us the most interesting part follows. It is a *Tableau Comparatif* of certain analogous properties of the hyperbola, the *sphéri-focale*, and the *focale* (6); a table which is simply an inversive restatement of certain known properties of the rectangular hyperbola. Of the six properties so listed we shall quote as examples only two, the second and third.

" Hyperbole."	" Sphéri-focale."
2. " Les trois diagonales de l'hexagone circonscrit se croisent dans un même point.	2. " Dans un hexagone, circonscrit à la sphéri-focale et composé d'arcs de cercles, passant par le nœud, si on joint les sommets opposés par des arcs de cercles assujettis aussi à passer par le nœud, ces trois arcs se couperont dans un seul point.
3. " Une corde passant toujours par un point fixe, les tangentes menées à ses extrémités se coupent toujours sur une même droite."	3. " Un cercle passant par le nœud et un point fixe, coupe la focale en deux points, par lesquels si on mène deux cercles tangents à la courbe et passant par le nœud, l'intersection de ces deux cercles sera toujours sur la même circonférence."

(5) Some writers of the last century (cf. TOWNSEND's *Modern Geometry*) would say that the infinite line of the projective plane projects stereographically into the pole (considered as a point circle) of the sphere. As a consequence therefore the two infinite points of an hyperbola arise by this projection from the doublepoint of the *sphéri-focale*. In the text however we use the inversive terminology.

(6) In the *Encyk. Math. Wiss.* III C5, Art. 49, p. 515, we find the statement that according to DANDELIN this *focale* is the inverse of the equilateral hyperbola with respect to a center of inversion lying on the hyperbola. This statement is misleading in that DANDELIN does *not* call it the inverse curve; indeed he never uses the term in that sense.

The statements for the *focale* are the same as those given for the *sphéri-focale*.

The study of stereographic projection (7) seems to have been a popular one at this time, and the fact that it is a special case of space-inversion is indicative of its importance in the present study. In passing we might mention a second work by DANDELIN in the *Nouveaux Mémoires*, t. IV, "*Mémoire sur l'emploi des projections stéréographiques en géométrie*," which was read at the session of May 7, 1825. Therein he solves the problem of APOLLONIUS "to construct a circle touching three given circles" by this method of projection.

The last and for us the most important of DANDELIN's papers which we wish to present here is that one entitled "*Sur les intersections de la sphère et d'un cône du second degré*," read June 4, 1825. (8) We shall give his procedure in some detail, for that only will show how he was led to his final result.

He remarks that the pedal curve of a parabola, ellipse, or hyperbola is a *focale*, a conchoid, or a lemniscate; and that he adopts the name "lemniscate" for all these pedal curves of conics.

Lemniscates are in general envelopes of a moving circle whose center lies on a conic and which passes through a fixed point. Consider P and P′, two adjacent points on a given conic C, and A a fixed point in the plane of C. Let the perpendiculars from A onto the tangents at P and P′ meet them respectively at D and D′, which are points on the lemniscate. If Q is the intersection of the tangents at P and P′ the circle on AQ as diameter passes through D and D′. Now as P′, moving along C, approaches P, D′ moves along the lemniscate and approaches D; and the circle on AQ as diameter approaches the circle on AP as diameter. This last circle has its center at M, the midpoint of AP, and is tangent to the lemniscate at D. The locus of M is a conic C′ similar to C.

If we are given the conic C′ and the fixed point A any circle

(7) G. SARTON in his *Introduction to the History of Science*, Vol. 1, p. 193 attributes this method of projection to HIPPARCHUS (second century B.C.). PTOLEMY of Alexandria (second century A.D.) explained the theory in his *Planisphaerium*. A German translation of a Latin version of this work has been published in *Isis*, v. 9 (1927), p. 255.

(8) *Nouveaux Mémoires... de Bruxelles*, t. IV (1827), pp. 3-10.

which passes through A and whose center M lies on C′ touches the lemniscate. From the foregoing the following construction of the point of contact presents itself. Draw the tangent MT to C′ and onto this tangent drop from A a perpendicular. This perpendicular will cut the circle at D, the point of contact with the envelope, and MD will be normal to the envelope. If E is the diametrally opposite point to D in the circle then the radii MA and ME make equal angles with the tangent to C′ at M. Hence considering A as a point source of light and C′ as a reflecting curve, the rays ME envelope the corresponding caustic curve; moreover the tangents to the caustic are normals to the lemniscate. Otherwise stated the *various varieties of lemniscates are involutes of the caustics by reflection of conics.*

If in the lemniscate we inscribe a hexagon whose sides are circles passing through the fixed point A, the opposite sides intersect in pairs in three points which lie with A on a circle. Consider six tangents 1, 2,..., 6 to the conic C′ which cut successively at 12, 23, ..., 61. To the tangent n corresponds the point D_n of the lemniscate and the tangent n is the perpendicular bisector of AD_n. The circle through A with center 12 passes through D_1 and D_2, etc. These six circles AD_1D_2, AD_2D_3, ... form a type of hexagon with circular sides meeting at A and having vertices D_n. The circles AD_1D_2 and AD_4D_5 intersect at two points A and B where B is the image of A in the diagonal line joining vertices 12 and 45 of the rectilinear hexagon circumscribing the conic C′. Moreover, every circle whose center is on this diagonal and which goes through A must also go through B. Similarly it can be shown that the circles whose centers are on the diagonal joining 23 and 56 and which pass through A must also go through C, the second point of intersection of the circles AD_2D_3 and AD_5D_6; and those circles whose centers lie on the join of 34 and 61 and which pass through A must also go through D, the second point common to the circles AD_3D_4 and AD_6D_1. The three diagonals of the rectilinear hexagon meet at a point I and therefore the circle whose center is I and which passes through A passes through B, C, and D; which proves the theorem.

Projecting the lemniscate, considered as an envelope of a system of circles, upon a sphere we have there a curve which possesses the same properties with regard to circles and intersections as

the lemniscate. Now take A′, the projection of A on the sphere, for a pole and project this spherical curve onto a plane perpendicular to the line joining the pole and the center of the sphere. All the circles through A′ project into straight lines; whence it follows that, in this projection of the spherical curve, if we inscribe any rectilinear hexagon, the sides of that hexagon will cut in three collinear points. It is evident that this projection is a conic. Hence *the spherical lemniscate is the intersection of a sphere and a cone of the second degree whose vertex lies on the sphere*. Otherwise stated we have this result : that for a given lemniscate there is a conic which can reproduce the lemniscate by a double stereographic projection.

Let the fixed point A be the center of a sphere of arbitrary radius R and CEF the intersection of the sphere with the plane of the lemniscate. Let N and S be the extremities of the diameter perpendicular to CEF, N being above and S below the plane. The double stereographic projection here consists of (1) a projection from plane to sphere with S as pole followed by (2) a projection from sphere to plane with N as pole. With the sphere so situated A projects by (1) to N and then by (2) to infinity. If D is any point on the lemniscate, the line SD projects from N into AD. To find the projection of the point where SD cuts the sphere, imagine a plane through SD and tangent to CEF at C; this plane will cut the sphere in a circle through S and tangent to CEF, which circle projects from N into a circle through A and tangent to CD at C. AD will cut this circle at B which is the projection from N of the intersection of SD with the sphere. All points B so constructed will be points of the conic which reproduce the lemniscate.

If r is the radius vector AD (of the lemniscate) and r' the corresponding radius vector AB (of the conic) then

$$rr' = R^2.$$

This, as DANDELIN points out, gives a new method of constructing lemniscates. Nor are we led to believe that this concludes his researches along this line, for although the above example of a transformation by inversion is inserted rather casually, he brings his paper to a close with the following remarks :

" Lorsqu'on a ainsi construit une courbe du second degré génératrice de la lemniscate, il est commode de s'en servir pour

déterminer toutes les circonstances du cours de cette dernière; on peut par son aide en construire les cercles osculateurs, les tangentes, en déterminer les points singuliers; mais comme toutes ces choses sont faciles pour ceux qui auront lu avec quelque attention notre *Mémoire sur les projections stéréographiques*, nous n'en parlerons pas davantage.

" Il y a aussi sur ces courbes des recherches analytiques très-curieuses, mais dont je traiterai ailleurs, car ici je ne me suis proposé que donner un nouvel exemple de l'emploi des projections stéréographiques."

3. — QUETELET (1796-1874)

DANDELIN's theorem concerning lemniscates as involutes of the caustics of conics was not original with him. QUETELET, his friend, and indeed the one who proposed DANDELIN for membership in the Brussels Academy on March 4, 1822, had for some time been interested in the subject of caustic curves. In his " *Mémoire sur une nouvelle manière de considérer les caustiques, produites, soit par réflexion soit par réfraction* " (9) he points out that the caustic by reflection for any curve illuminated by a point source of light is the evolute of another curve (the secondary caustic) which is the envelope of a system of circles having their centers on the reflecting curve and passing through the point source of light. The secondary caustics of conics have been studied separately by many people and fall into three distinct classes : (1) those which have a node, (2) those which have a cusp, and (3) those of a class which does not appear to have been investigated. In his investigation he notices the analogy between these curves and conics which is brought out by a double stereographic projection. In fact he gives the theorem which DANDELIN was to discuss later, namely, that this type of secondary caustic projects onto a sphere as a curve which is the intersection of a sphere and a cone of second degree whose vertex lies on the sphere. This cone has as base an hyperbola, parabola, or ellipse, depending on whether the first projection is of a secondary caustic

(9) *Nouveaux Mémoires, etc.*, t. III (1826), pp. 89-140.

of class (1), (2), or (3) above; so that for such a curve a great number of properties can be deduced after the fashion of DANDELIN's *Tableau Comparatif*.

The remainder of this long paper contains among other things a rather detailed study of these curves and, for our purpose, is of little consequence. There are a few points, however, which should be mentioned. We find from a note at the end that QUETELET presented this memoir to the Academy on Feb. 3, 1823, but later found it necessary to make some additions; hence it was not read as a whole until Feb. 28, 1825. He also mentions his pleasure in finding, upon reading the proofs, that he and STURM (10) have independently arrived at many of the same results, including that one of the analogy with conics. From the dates given above it appears that DANDELIN's "*Sur les intersections de la sphère et d'un cône du second degré*," summarized in the preceding section, had already been anticipated by QUETELET and also, to some extent, by STURM. Almost entirely are DANDELIN's results found somewhere or other in these earlier papers. With one exception however; and that is his construction of lemniscates from conics, and conversely, by means of the relation $rr' = R^2$ between corresponding radii vectores. (11) This would lead one to think that perhaps DANDELIN did not consider this final result of his article to be as casual as it appears; that he gave anew those theorems (which he certainly realized were not original with him) simply to pave the way for this inversive relationship between the so-called lemniscates and conics. However that may be, events were certainly shaping themselves to this end.

On Nov. 5, 1825 QUETELET read before the Brussels Academy a paper entitled "*Résumé d'une nouvelle théorie des caustiques*,

(10) We have not summarized any of CH. STURM's papers because they do not include anything pertinent to our discussion. They are found in GERGONNE's *Annales de Mathématiques pures et appliquées*, Vols. 14-17. In the same volumes are also found several papers on caustics by GERGONNE in one of which he gives a résumé of preceding work on the subject.

(11) In a solution of a problem in GERGONNE's *Annales*, t. 14 (1823), pp. 17-23, STURM gives this same relation in the very special case of an equilateral hyperbola and its pedal curve with respect to its center. Making use of this fact he then describes a construction for the pedal curve when the hyperbola is given. In giving this relation however STURM does not suggest the idea of a geometric transformation such as we find in DANDELIN's work.

etc." (12) In the introduction he says that after long seeking a method to simplify the determination of caustics he has been led to a very useful principle; the basis of which consists in considering caustics in general as evolutes of other curves easier to determine, either by analysis or graphical construction. And that these curves which he wishes to substitute for caustics can be produced by a uniform method of generation. By the principle already established in his earlier paper the theory of caustics reduces to the theory of envelopes and evolutes; and he observes that the point source of light, the reflecting curve, the caustic, and its involute (the secondary caustic) have with regard to each other certain relations such that it is enough to know two of these four things to deduce the other two provided that the two given are not the latter two. This observation, he says, connects many things heretofore considered as isolated.

QUETELET then continues for many pages establishing his theory, illustrating his various points, considering not only reflecting but also refracting curves, and so on. The gist of his argument is this : Consider a point source of light R and a reflecting curve (P). The ray emanating from R to the point P of (P) is reflected in the direction PC, the rays RP and PC making equal angles with p, which is the tangent at P. A circle with center P and radius PR cuts PC produced in the opposite direction at Q_1 which is a point on the secondary caustic of (P). Now on the polar reciprocal of the curve (P) with respect to a circle of arbitrary radius r and center R there is the point Q′ corresponding to the tangent p. Let N and S be two diametrally opposite points on a sphere with center R and radius r, NS being perpendicular to the plane of (P). By a stereographic projection of the plane from N onto the sphere followed by a like projection of the sphere from S onto a plane through N and parallel to the plane of (P) we transform the secondary caustic into the polar of (P) and at the same time the polar into the secondary caustic.

If RQ′ cuts p at Q and TT′ is the chord of contact of the tangents from Q to the polarizing circle it is known that RQ and TT meet at Q′. In the right triangle QTR we have

(12) « Résumé d'une nouvelle théorie des caustiques, suivi de différents applications à la théorie des projections stéréographiques. » In the *Nouveaux Mémoires*, t. IV (1827), pp. 79-109.

$$RQ.RQ' = r^2.$$

As Q′ traces the polar curve (Q′), the point Q traces a curve (Q) such that its radius vector RQ is inversely proportional to the corresponding radius vector of (Q′). Hence he calls (Q) the *inverse curve* of (Q′). Now if each radius vector RQ be prolonged to Q_1 such that $RQ = QQ_1$ it is evident that Q_1 traces a curve (Q_1) which is similar to (Q); and (Q_1) is the secondary caustic of the given curve (P). Therefore *the polar of a given curve has for its inverse a curve similar to the secondary caustic of the given curve*. This in conjunction with the theorem that *the polar of any plane curve after two successive stereographic projections becomes similar to its inverse, and reciprocally* gives the relationship existing between a double stereographic projection (as in the preceding paragraph) and an inversion.

And QUETELET does not content himself with a geometrical statement of this method of transformation. In a note he shows that the inverse of a curve $f(x, y) = 0$ with respect to the circle $x^2 + y^2 = r^2$ is obtained analytically by the transformation

$$x = \frac{x'r^2}{x'^2 + y'^2}, \qquad y = \frac{y'r^2}{x'^2 + y'^2}$$

and this he uses as a simple means of deducing the equation of the polar curve from the equation of the pedal curve for, as we have seen, the two curves are mutually inverse.

For the time being we shall leave QUETELET with his discovery of inversion, merely remarking that DANDELIN possibly should receive some of the credit, and focus our attention on the works of the geometers STEINER, MAGNUS, and PLÜCKER in Germany.

4. — STEINER (1796-1863)

Some thirty years after STEINER's death a box containing his personal and scientific papers was found in the city library of Berne. (13) Professor F. BÜTZBERGER of Zürich undertook the task of examining these manuscripts; and upon the completion of his work he had bound and deposited in the library of the Uni-

(13) ARNOLD EMCH, "Unpublished Steiner Manuscripts" in *The American Mathematical Monthly*, v. 36 (1929), pp. 273-275.

versity of Berne ten volumes of various STEINER manuscripts. It appears, however, that BÜTZBERGER kept the most important papers; possibly for the purpose of later publishing them when time permitted. And before his death BÜTZBERGER did publish a monograph on his investigations of bicentric polygons in which he included a most interesting fragment from STEINER's posthumous papers. (14) These few pages, dated February 8, 1824, show STEINER's mind at work as he first approached his discovery of inversion. As briefly as possible we shall summarize the contents of this manuscript from BÜTZBERGER's edition of it.

STEINER begins his notes with a theorem to the effect that if given a fixed point S and a circle (M), with center C and radius R, the two points on any secant of (M) through S, which divide in a given ratio the distances from S to the two points of intersection of this secant with (M), lie on a circle which has with (M) the point S as external center of similitude.

Then, he says, if Q is the point which divides the *chord* of each secant in a given ratio the locus of Q is a circle when S lies on the circumference of (M) or when the ratio of division is one-half; otherwise Q traces a closed curve (of a type which varies according to the position of S with respect to the circle (M), etc.). Now let SNQP be a secant through S which cuts (M) at P and whose chord is bisected by N; Q is the point which divides this chord in a given ratio, i.e., NQ/NP $= m$, a constant. Putting SC $= a$, SQ $= \rho$, and the angle CSQ $= \varphi$, the point Q traces the curve whose polar equation is

$$\rho = a \cos \varphi \pm m \sqrt{R^2 - a^2 \sin^2 \varphi},$$

The cartesian equation of this curve,

$$(1) \qquad (x^2 + y^2 - ax)^2 = m^2 [R^2 x^2 - (a^2 - R^2) y^2],$$

shows S to be a singular point.

Here STEINER ends his discussion of this curve. But it should be noticed that an inversion with regard to S (the origin) as center transforms this fourth order curve into a conic; into an ellipse, hyperbola, or parabola according as (1) has an isolated doublepoint, a real doublepoint, or a cusp. This transformation is easily

(14) F. BÜTZBERGER, *Über bizentrische Polygone, Steinersche Kreis- und Kugelreihen und die Erfindung der Inversion*, TEUBNER, Leipzig 1913. See also the review of this pamphlet by EMCH, *Bulletin of the American Mathematical Society*, v. 20 (1914), pp. 412-415.

effected by using the formulas given at the end of the preceding section.

Continuing we find next a statement of inversion or, to quote STEINER,

" Von der Wiedergeburt und der Auferstehung."

" Sind zwei beliebige Kreise (M) und (m) gegeben, so bilden die Punkte, welche dem Kreis (m) als Punkte des gleichen Verhältnisses in bezug auf den Kreis (M) entsprechen, einen Kreis (m_1), der mit (m) den Punkt C zum äusseren Ähnlichkeitspunkt hat... Der Kreis (m_1) ist also die Wiedergeburt des Kreises (m) und umgekehrt."

A digression is necessary. PONCELET (15), as BÜTZBERGER points out, had earlier considered the two following correspondences between the points of two circles: On every secant through a center of similitude S of the two circles there are two pairs of points A and A′, B and B′ whose corresponding radii are parallel. Now (1) the correspondence which pairs each point A of one circle with the point A′, whose radius is parallel to that of A, of the other circle, Poncelet terms a " direct homology " while (2) the correspondence which pairs with A, the point B′, whose radius is not parallel to that of A, he terms an " inverse homology." And he shows that in the case of (2) the relation

$$SA.SB' = SB.SA' = \text{constant}$$

always holds. But PONCELET concerns himself principally with only the first of these transformations, that of similarity; and it is the second one which STEINER is referring to in the paragraph just quoted. For he follows the quotation which we have given with the statement that

$$Cp.CP = R^2,$$

where p and P are corresponding points (in the sense of (2) above) of (m_1) and (m) respectively, and R is the radius of (M). We shall have more to say about this later.

The next few pages of the manuscript contain the statements and proofs of several fundamental facts of inversion. Namely, that the three circles (M), (m), and (m_1) are coaxal; that the inverse of a straight line is a circle through C, the center of inver-

(15) *Traité des propriétés projectives des figures*, Paris 1822, pp. 130 ff.

sion, and conversely. But what does STEINER mean by "*die Auferstehung*"? We again quote:

"Nähern sich die Kreise (m), (m_1), so wird ihr Unterschied geringer; werden beide gleich, so fallen sie zusammen und es ist die Tangente aus C gleich R und folglich muss dieser Kreis sich selbst erzeugen; d. i. seine Auferstehung."

In reading this fragment from STEINER's papers it is evident that he is working over a new idea, that he is feeling his way, so to speak. It is so different from his published works; it is disconnected and lacks the preciseness and clarity which are characteristic of his writings. For this reason we have touched only the high spots of his paper. Before going on, however, we should say that STEINER's thoughts here were not confined to inversion as regards circles only. He explicitly states that the inverse of a parabola is a closed curve passing through the center of inversion C; that the inverse of an hyperbola always goes through C and the asymptotes transform into two asymptotic circles. And then he asks: What is the inverse of an ellipse; if the ellipse goes through C what is its inverse; and what is the inverse of a parabola or hyperbola if the vertex lies at C? Parallel lines invert into tangent circles; what then do parallel circles invert into?

STEINER gives us no hint as to how he arrived at the knowledge that a parabola or hyperbola inverts into a closed figure through the center of inversion. Is it possible that he obtained this result analytically from a consideration of the quartic curve whose equation we have given at the beginning of this section? And if so could he not, by the same means, have answered himself the questions which he proposes immediately afterwards?

So much for STEINER's manuscript. The remainder of BÜTZBERGER's article presents the conclusions which he draws from this and other papers of STEINER's which were found in the library at Berne. In particular he mentions a paper by one of STEINER's students on stereographic projection (written in October, 1826). STEINER might have arrived at the discovery of inversion by this means as did the Belgians, DANDELIN and QUETELET, but that does not seem probable from a reading of the paper which we have just summarized. BÜTZBERGER is of the opinion that STEINER gave an elaboration of his *Wiedergeburt und Auferstehung*

in a lost manuscript entitled "*Abspiegelung*," to which STEINER refers in another unpublished fragment dated December, 1824.

That STEINER would elaborate on his theory at some time seems natural from certain passages in his published works, notably in the two papers "*Einige geometrische Betrachtungen*," written in March 1826, and "*Die geometrischen Constructionen ausgeführt mittelst der geraden Linie und eines festen Kreises*," which appeared in 1833.(16) Each of these papers contains much that is recognizable now as inversion. In particular, in the former we find a discussion of two corresponding points X and Y of two given circles, having A as an external center of similitude, such that A, X, and Y are collinear and the product AX.AY is equal to a certain constant, which STEINER has earlier defined as the common power of the two circles. Two such points, he writes, "seien potenzhaltend in Bezug auf den Aehnlichkeitspunct A." And in the latter paper he says that two *potenzhaltende* points need not lie on the given circles but only on a ray (through a center of similitude) so that the product AX.AY is equal to the fixed constant. This of course is simply the ordinary definition of inverse points. STEINER also speaks of points as *potenzhaltende* with respect to the internal center of similitude in which case the inversion is of the elliptic type. (17)

BÜTZBERGER is convinced that STEINER not only knew but repeatedly made use of the conformality property of the transformation of inversion; that many of his solutions and theorems which he published without proof were arrived at in that way. But for some unexplained reason STEINER preferred to keep his discovery a secret. One other of his posthumous manuscripts (which has but recently been published) on the geometry of the circle and the sphere (18), places STEINER at once as one of the important investigators of that field. He goes farther than any of his contemporaries and indeed many of the results found

(16) Both these papers are found in STEINER's *Gesammelte Werke*, Bd. 1.

(17) This consists of an inversion with a negative measure $-k^2$; i.e. an inversion in a circle of imaginary radius. In this case two inverse points lie on opposite sides of the center of inversion.

(18) *Allgemeine Theorie über das Berühren und Schneiden der Kreise und der Kugeln, etc.* By JAKOB STEINER. Edited by FUETER and GONSETH, ORELL FÜSSLI, Zürich and Leipzig 1931. Reviewed in *Bulletin of the American Mathematical Society*, v. 37 (1931), pp. 793-795, by T. R. HOLLCROFT.

there were not known until their discovery some years afterwards by others. If STEINER knew any more of the theory of inversion than his published works and manuscripts show it is certainly a mystery why he kept that knowledge to himself; for the last-mentioned treatise would have been such an ideal setting for an exposition of the theory—even though he had elaborated on it in his paper on "*Abspiegelung*."

5. — MAGNUS (1790-1861)

We have previously mentioned PONCELET's correspondence of homologous points, direct or inverse, in his "*Traité des Propriétés Projectives*." Earlier in the same book (19) we find a discussion of a transformation by "reciprocal points" with respect to a system of coaxal circles or conics; according to BÜTZBERGER, the first example of a geometric transformation. A decade later (1832) MAGNUS in an article entitled "*Nouvelle méthode pour découvrir des théorèmes de géométrie*" (20) gives an analytical development of this transformation. It is of interest to us because of the fact that he cites, as a special case, the transformation of inversion.

Consider the one-to-one correspondence established between the points (x, y) of a plane P and the points (t, u) of a plane P′ by the (quadratic) transformation

$$\begin{aligned} At + Bu + C &= 0 \\ A't + B'u + C' &= 0, \end{aligned} \tag{1}$$

where A, B, C, A', B', C' are linear functions of x and y. To a point in P′ corresponds a point in P; to a line in P′ a conic in P through three fixed points, etc. MAGNUS develops this to a considerable extent and shows its connection with the theory of poles and polars. He then suggests the following special case of the equations (1) above : By a certain choice of coefficients (1) becomes

(19) Pp. 44 ff.

(20) *Journal für die reine und angewandte Mathematik (Crelle)*, Bd. 8 (1832), pp. 51-63.

$$axt + byu + 1 = 0$$
$$yt - xu = 0. \qquad (2)$$

Then we have

$$t = \frac{-x}{ax^2 + by^2},$$
$$u = \frac{-y}{ax^2 + by^2}.$$

And to the line

$$u = gt + h$$

of P′ there corresponds a conic of P, viz.

$$ax^2 + by^2 + y/h - gx/h = 0. \qquad (3)$$

Now whatever the values of g and h may be ($h \pm 0$), that is for any line in P′ (not passing through the origin), the first two terms of (3) remain the same. Hence to the lines of P′ correspond in P a system of conics similar and similarly placed, all of which pass through the origin which is one of the three fixed points of P. After citing several facts about this particular transformation MAGNUS remarks that if we take $a = b$ we have here a transformation in which circles correspond to straight lines and angles are preserved. (21)

The rest of this paper is concerned with a method of deriving, by means of the transformation (1), from a single projective theorem, a number of other theorems equally valid.

6. — PLÜCKER (1801-1868)

In the paper "*Einige geometrische Betrachtungen*," written by STEINER in 1826, we find a construction, but without proof, of MALFATTI's problem, viz., to describe in a given triangle three circles which touch one another and each of which touches two sides of the triangle. He offers this construction as an example of the fertility of the theorems developed in the preceding part of his paper. As a result much time and energy was expended

(21) In *Sammlung von Aufgaben und Lehrsätzen aus der Analytischen Geometrie*, by L. J. MAGNUS, Berlin, 1833, pp. 236, 290, we find additional applications of this particular transformation. The inverse curve of a circle, an equilateral hyperbola, and a parabola is found to be respectively a circle, a lemniscate, and a cissoid.

by others in attempting to prove this construction of STEINER's. Among the various solutions offered we have that given by PLÜCKER in an article entitled " *Analytisch-geometrischen Aphorismen.*" (22) In a footnote PLÜCKER says ," Diese Construction ist im Wesentlichen keine andere, als die vom Herrn STEINER im ersten Bande dieses Journals (S. 178) aufgestellte. Es findet sich daselbst keine Andeutung eines Beweises. Die einleitenden Worte des Verfassers : ' Um die Fruchtbarkeit der in den Paragraphen (I., II., III.) aufgestellten Sätze an einem dazu geeigneten Beispiele zu zeigen, fügen wir die geometrische Lösung und zugleich die Verallgemeinerung der Malfattischen Aufgabe, jedoch ohne Beweis, hinzu', könnten demjenigen, der, wie ich von mir bekennen muss, keine Idee davon hat, wie die Construction jener Aufgabe, dem Wesentlichen nach, auf den in den angeführten Paragraphen entwickelten bekannten Sätzen über Chordalen, zugeordnete Pole und Ähnlichkeitspuncte beruhen möge, den Gedanken aufdrängen, dass die gegebene Construction nicht bewiesen sei..."

PLÜCKER does prove this solution of the problem and its generalization by geometrical and analytical methods and follows it with an account of his *neues Übertragungs-Princip* which is essentially an analytical development of the transformation of inversion. BÜTZBERGER, in his account of the discovery of inversion, seems unduly disparaging in his remarks concerning PLÜCKER's contribution. The counts upon which BÜTZBERGER bases his opinions are two in number. First, he says, PLÜCKER in the note quoted above takes the liberty to express the suspicion that STEINER himself could not prove the construction which he gave of MALFATTI's Problem. Certainly PLÜCKER acknowledged that *he* had no idea how the preceding part of STEINER's paper bore on the solution as given; and therefore *to such a one as himself* (i.e. PLÜCKER) was the thought suggested that the given construction could not be proved. But that PLÜCKER did succeed in proving the construction is evidence enough that the thought was only suggested. To say that this note of PLÜCKER's suggests STEINER's inability to prove his own construction is most assuredly reading into it even more than it implies.

Secondly, BÜTZBERGER says that PLÜCKER's method of trans-

(22) Crelle's *Journal*, Bd. 11 (1834), pp. 117-130, 219-225.

formation had been anticipated and formulated analytically by MAGNUS (in the paper mentioned in Section 5) two years earlier. We have already seen how little attention MAGNUS gave to this transformation and we shall show later that PLÜCKER carried his exposition of the principle much further than any of his predecessors, MAGNUS included. But before going on with this there is another point worth mentioning; namely, that it is doubtful whether one can say that MAGNUS did precede PLÜCKER. For the reason that although PLÜCKER's paper was published in 1834 and MAGNUS's paper was published in the same journal in 1832, nevertheless PLÜCKER's paper is definitely dated at Bonn, October 1831, the year before MAGNUS' article appeared. Moreover, the beginnings of PLÜCKER's transformation principle are found in volume 1 (pp. 93 ff.) of his *Analytisch-Geometrische Entwicklungen*, published at Essen in 1828, thus antedating MAGNUS' paper by four years.

PLÜCKER's exposition of inversion is given in Section V of his "*Analytisch-geometrischen Aphorismen*," (p. 219-225), which is entitled "*Über ein neues Übertragungs-Princip*." He defines inverse points as two points which lie on a line going through the center of a given circle and such that each lies on the polar line of the other with respect to this circle. He says that two such points will be called "zugeordnete Pole in Beziehung auf den gegebenen Kreis." Furthermore, the locus of the inverse of a point lying on the circumference of a given circle is another circle; and two such circles he names "zugeordnete Kreise." These two inverse circles have with the circle of inversion (Hülfs-Kreis) a common radical axis and the center of the latter circle is a center of similitude of the two inverse circles. If a circle passes through the center of inversion it has as inverse a straight line, and conversely.

Throughout PLÜCKER emphasizes the fact that by means of this transformation any geometric theorem which concerns only relations of position and angles with regard to arbitrary circles and straight lines gives rise to a new theorem concerning like relations with regard to other arbitrary circles and circles passing through a fixed point. He is obviously aware of the conformality of the transformation.

In paragraph 5 he shows that a system of concentric circles inverts

into a system of coaxal circles; and that the radical axis of the inverse system is the radical axis of the circle of inversion and that circle of the concentric system which passes through the center of inversion. Moreover, all the circles of the inverse system have a pair of common inverse points; which are respectively the inverse of the center of the given concentric system and the center of inversion itself. Indeed, a very complete answer to STEINER's question : " Into what do parallel circles invert ? "

In conclusion he indicates the solution of the problem of inverting two given circles into two circles of equal radii; then the corresponding problem for three circles; and finally the Apollonian Problem. Certainly PLÜCKER was not as original in his discoveries as he perhaps thought himself to be, but the fact remains that he had more to say about the basic principles of the transformation than any of the others before him. BÜTZBERGER's criticism (23) that PLÜCKER's approach was not purely geometrical is perhaps a just one; on the other hand, in view of the results, we should not be too meticulous concerning the method as long as it is a valid one. This of course is simply a mathematical observation and not a moral one !

Characteristic of all the papers which we have up to this point examined is the fact that not one of them contains more than a definition of inversion together with a few applications in a very restricted sense. Moreover, upon looking back we see that each of the various pioneers has apparently (from what he has written) arrived at his discovery by a different route. DANDELIN and QUETELET were led to their formulation of the principle by a study of stereographic projection; STEINER through the theory of similar figures and the correspondences of homologous points of two circles; MAGNUS came upon it as a special case of a more general one-to-one point transformation of one plane upon another; and finally PLÜCKER by way of the theory of poles and polars. For a systematic development of the theory of inversion from a definition such as we give today, we turn to Italy and the work of BELLAVITIS.

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(23) Is this an echo of STEINER's well-known objections to PLÜCKER's use of analytic methods in geometry ?

7. — BELLAVITIS (1803-1880)

GIUSTO BELLAVITIS wrote much on inversion. His first published paper on this subject seems to be his " *Teoria delle figure inverse, e loro uso nella Geometria elementare* " (24) which appeared in 1836. That he was aware of the fact that others had suggested such a transformation is evident from his statement in the second paragraph : " Mi è noto pel *Bulletin Universel* che i QUETELET, DANDELIN, STURM ec. si occuparono delle figure inverse, servendosi specialement della *projezione stereografica;* ma non conoscendo io le loro Memoire originali ignoro se m'abbiano interamente prevenuto, o se limitandosi a considerare la natura delle linee tra loro inverse, e la eguaglianza degli angoli sotto cui si tagliano, abbiano trascurate le relazioni fra le distanze dei punti e fra le inclinazioni delle rette che gli uniscono." An examination of the *Bulletin Universel* (25) shows that BELLAVITIS was referring to an abstract of QUETELET's paper on caustics (the second one summarized in Section 3); and in that abstract, references are made to DANDELIN and STURM as having done work in the same field.

As a matter of fact, BELLAVITIS presents an exceedingly complete discussion of inversion. We have of necessity gone over the fundamentals of the subject in the preceding sections so often that another repetition would be wearisome to the reader. Hence we pass over the first part of the article under consideration; the elements are all there and stated with clarity and in detail. (26) His principal weapon of attack is his so-called *metodo delle equipollenze* (27) which is essentially a representation of directed segments in the plane.

The second part of the paper discusses the elements of inversion

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(24) *Annali delle Scienze del Regno Lombardo-Veneto*, Padova, t. VI (1836), pp. 126-141.

(25) *Bulletin des Sciences Mathématiques, première section du Bulletin Universel*, t. 12 (1829), No. 117, p. 193.

(26) He proves not only the conformality of the transformation but also the invariant character of its cross-ratio.

(27) For an explanation of this method see his papers in the *Annali delle Scienze, etc.*, Padova, t. V (1835) and t. VII (1837). Also the *Encyk. Math. Wiss.* III ABll, Art. 4, p. 1293.

in space. This is based on geometrical considerations, for, as he points out, his *metodo delle equipollenze* does not permit a space analogue. His principal result here is that stereographic projection is an inversion of a sphere into a plane, the center of inversion having been taken on the sphere.

Part three considers the inverses of conic sections. He ties up his discussion with the theory of caustics in much the same way as did his predecessor QUETELET; the curves which QUETELET called *secondary-caustics* BELLAVITIS names *involute-caustics*. Then follows an individual study of the inverses of an ellipse, hyperbola, and parabola respectively; and for each of these inverse curves he deduces by inversion a number of properties from the known properties of the corresponding conic section.

The paper concludes with certain remarks of an analytical nature concerning the equations of the inverses of conics. If space permitted it would be interesting to make more explicit mention of his results; but since these results depend more or less on his *metodo delle equipollenze*, which we have not explained, we refer the reader to the original memoir and pass on to other considerations.

8. — LATER FORMULATIONS OF THE PRINCIPLE

Probably no other discovery has been so frequently made and remade as that of inversion. Our investigation of its origins has taken us to Belgium, Germany, and Italy; and now we can complete the circuit. For we find in the first (and only) volume of the *Transactions of the Dublin Philosophical Society* (1842), page 145, an article "*On the Application of a New Principle to the Geometry of Curves and Curved Surfaces*," by J. W. STUBBS; and the new principle is inversion. STUBBS says nothing about any earlier work on the subject except that of INGRAM who seems, as STUBBS remarks, to have discovered the same thing simultaneously and independently; and moreover to have suggested the same term *inverse* to express this relationship between curves. On page 58 of the same volume we find J. K. INGRAM's paper, "*Geometrical Properties of Certain Surfaces*," which is the one to which STUBBS was referring. INGRAM introduces his statement

of inversion in discussing a certain surface of elasticity; and from the context one gathers that of the two papers this latter one takes precedence. And on page 159 we find another paper by INGRAM, viz. "*On the Properties of Inverse Curves and Surfaces*," in the writing of which the author refers to both of the two papers mentioned above. And STUBBS, not to be outdone, elaborates his theory in two papers published in 1843 and 1844. (28)

It is very curious that one finds so many "independent" discoveries; for, notwithstanding the five publications just cited, WILLIAM THOMSON addressed from Cambridge, England several letters (29) to LIOUVILLE (the first dated October 8, 1845) in which he discusses the solution of a certain problem in electricity by his "principle of images" or "principle of reciprocal points" which are precisely inverse points with respect to a sphere. LIOUVILLE moreover adds a note to one of these letters in which he treats the analytic theory of THOMSON's transformation and gives to it the name (still used by French writers) of *transformation par rayons vecteurs réciproques*. He furthermore proves its conformality im kleinem; and also uses the transformation to find the lines of curvature of the envelope of a sphere touching three given spheres—a problem previously solved by DUPIN.

To be as complete as possible in our discussion we mention also W. ROBERT's letter (30) to LIOUVILLE, dated Nov. 10, 1847 at Dublin, in which the writer suggests a transformation by which a curve $f(r, \omega) = o$ becomes $f(R^{+}_{-}{}^{n}\, n\,\Omega) = o$; and this, for $n = -1$, reduces to the transformation considered by STUBBS (*Phil. Mag.* 1843).

The culmination of all these various formulations of the principle of inversion (although the author seems to have been acquainted only with the work of L. J. MAGNUS) occurs in 1855 in the "*Theorie der Kreisverwandschaften in rein geometrischer Darstellung*," by A. F. MÖBIUS, which follows an earlier paper (1853) entitled

(28) *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, 3rd Ser., v. 23 (1843) and v. 25 (1844).

(29) *Journal de Mathématiques pures et appliquées (Liouville)*, Ser. 1, t. 10 (1845), pp. 364-7, t. 12 (1847), pp. 256, 263. In this connection see also THOMSON's article in *The Cambridge and Dublin Mathematical Journal*, v. 3 (1848), pp. 131-148, 266-274, and MAXWELL's *Treatise on Electricity and Magnetism*, Oxford 1881, Chap. XI, where expositions of THOMSON's theory are given.

(30) Liouville's *Journal*, Ser. 1, t. 13 (1848), pp. 209-220.

"*Ueber eine neue Verwandschaft zwischen ebenen Figuren*" wherein MÖBIUS develops the fundamentals of his theory. We do no more than mention these articles for they are both found in the second volume of his *Gesammelte Werke* and are easy of access.

9. — SUMMARY

Since our guiding purpose has been to ferret out the origins of inversion rather than to find the proper person upon whom to bestow the honor of discovery, we have perhaps been a little confusing in regard to the relative order of the various papers presented. We offer therefore a chronological summary:

(1) DANDELIN (April 1, 1822) gave his *Tableau Comparatif* for hyperbola and *focale*.

(2) QUETELET (Feb. 3, 1823) compared secondary caustics and conics in the way suggested by DANDELIN.

(3) STEINER (Feb. 8, 1824) defined his *Wiedergeburt* in a manuscript note published by BÜTZBERGER in 1913.

(4) DANDELIN (June 4, 1825) deduced the relation $rr' = R^2$ between corresponding radii vectores of his so-called lemniscates and conics and thus arrived at a new construction of the former curves.

(5) QUETELET (Nov. 5, 1825) defined the *inverse* of a curve.

(6) PLÜCKER (October 1831) explained his *neues Übertragungs-Princip* which was published in 1834.

(7) MAGNUS (1832) mentioned a special case of a more general transformation without naming it.

(8) BELLAVITIS (June 1836) gave a complete exposition of the theory of inverse figures.

(9) INGRAM (1842) to MÖBIUS (1853).

10. — CONCLUSION

The above summary shows STEINER to have been the first to define inversion. Why did he not publish this method of transformation which he discovered? Until the establishment of CRELLE's *Journal für Mathematik* in 1826 STEINER published

many, if not all, of his papers in GERGONNE's *Annales de Mathématiques;* and he makes sufficient mention of this last named journal to assure us that he read it with some regularity. He does not refer, however, to the *Nouveaux Mémoires* in which the articles of DANDELIN and QUETELET appear; and although we know that these *Mémoires* were sent to Berlin from 1821 on, it does not seem at all probable that STEINER knew of the papers referred to in items (1), (2), (4), and (5) of the preceding section. We make the suggestion then that perhaps STEINER felt that he had in his correspondence of *potenzhaltende* points a transformation just as effective for his purposes as that of *die Wiedergeburt und die Auferstehung*. For, in the first place, he obtained by this correspondence of *potenzhaltende* points the fundamental theorem of inversion, to wit : the inverse of a circle is a circle. (31) And, in the second place, all his applications are to problems of circles and spheres cutting under a constant angle. Indeed no less a one than THEODOR REYE (32), writing in 1879 and certainly unbiased in making his comparison, places PONCELET's principle of inverse homologous points and STEINER's principle of *potenzhaltende* points side by side as being only a short step from the principle of inversion. In other words the applications which STEINER made were such that his theory of *potenzhaltende* points was adequate for their treatment. From this point of view STEINER of course would have no particularly pressing reason for advancing his *Wiedergeburt* transformation.

BÜTZBERGER says that STEINER's discovery of inversion was induced by the following problem (and its space analogue) which appeared in Volume 11 of GERGONNE's *Annales*, namely : Given three circles in a plane, to determine the locus of a point P whose polars with respect to the three circles go through a point Q; and also to determine the locus of Q. STEINER's manuscript fragment does indicate that he had some such problem in mind

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(31) " Einige geometrische Betrachtungen," *Gesammelte Werke*, Bd. 1, p. 41. VIETA in his *Apollonius Gallus* (1600) also derived this theorem from like considerations together with the corollary that a circle transforms into a straight line under certain conditions; FERMAT (1679) extended the same to space. See *Encyk. Math. Wiss.* III AB9, Art. 17, p. 1030.

(32) *Synthetische Geometrie der Kugeln und linearen Kugelsysteme*, TEUBNER, Leipzig 1879.

and the solution of this problem we find in his treatise on the circle and the sphere, on page 55. But, and this bears out our previous point, in this solution STEINER does not invoke the *Wiedergeburt* transformation when dealing with inverse points; instead he falls back on the older theory of conjugate poles with respect to a circle (a well-known method which indeed was used by J. B. DURRANDE (33) about the same time in solving the same problem), a fact which might indicate that STEINER felt the old theory to be sufficient after all for the type of problem at hand.

Quite opposed to STEINER's reason for his invention we find that QUETELET introduced inversion for the purpose of showing a connection between secondary caustics and conics. MAGNUS and PLÜCKER were led on by the idea that inversion would prove to be a means of multiplying the theorems of geometry in much the same way as does the principle of duality or the theory of reciprocal polars. And the same might be said of BELLAVITIS although in a different sense. His use of inversion was more in the nature of an additional weapon of attack in proving theorems of geometry, to be used in conjunction with the other transformations of geometry. To cite only one of the several articles which he wrote on this subject we refer to his "*Principii della geometria di derivazione*" (34) where we find an elementary exposition of various geometric transformations such as those of similarity, projection, inversion, reciprocal polars, homology, etc.

Our study makes clear one more fact, albeit an unimportant one. That the name *inversion* was among the first given to the transformation; in fact it was the first appearing in print and moreover was the one consistently used by all except the German writers. An examination of the various methods of approach to the discovery gives an obvious explanation as to why this was

(33) See his solution in GERGONNE's *Annales*, t. 16, pp. 112-117, for October 1825. STEINER's solution apparently antedates this one.

(34) *Annali di Scienze Matematiche e Fisiche di Tortolini*, t. 5 (1854), pp. 241-256. See also his article "Sulla Classificazione delle Curve del Terzo Ordine" in *Memorie di Matematica e di Fisica della Società Italiana*, t. 25 (1855), pp. 1-50; and a letter to the editor of the *Annali di matematica pura ed applicata*, in t. 3 (1860), p. 60, wherein BELLAVITIS objects to an Italian journal crediting STUBBS with the discovery of inversion. A much earlier paper by BELLAVITIS on this subject is his "Saggio di geometria derivata" in t. 4 (1838), pp. 243-288, of the *Nuovi saggi della imperiale regia accademia di scienze lettere ed arti in Padova*.

XUM

so. The inverse relationship existing between corresponding radii vectores is not stressed by any of the Germans and is stressed by all the others.

To bring to a close a paper which has already exceeded its intended length we refer the reader to the bibliographies given by Dr. KARL DOEHLEMANN in the second part of his *Geometrische Transformationen* (35) for references to the growth of the theory of inversion from MÖBIUS on. The invariant theory of inversive geometry according to FELIX KLEIN's *Erlanger Programme* had its beginning in 1900 in a paper by KASNER (36), the basis of which is the theory of projective geometry upon a non-degenerate quadric; and differential inversive geometry had its inception with MULLINS, in 1917, and with others still later. (37)

Although it is the feeling of the present writer that everything of importance regarding the origins of inversion has been uncovered, nevertheless it must be borne in mind that the last word is rarely spoken and, in the subject just concluded, something earlier than anything we have discussed is perhaps yet to be found. Such a discovery would be most interesting.

Hamilton College BOYD C. PATTERSON.
February, 1932.

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(35) Sammlung Schubert, XXVIII, Leipzig 1908, GÖSCHEN. A more recent bibliography, which has just recently come to my attention, is found in the *Bulletin of the National Research Council*, No. 63, Washington, D. C., entitled "Selected Topics in Algebraic Geometry".

(36) *Transactions, American Mathematical Society*, v. 1 (1900).

(37) For a bibliography of this phase of inversive geometry see the writer's papers in the *American Journal of Mathematics*, v. 50 (1928) and v. 52 (1930).

The origin of our present system of notation according to the theories of Nicholas Bubnov

The work and theories of NICHOLAS BUBNOV, Russian historian of mathematics, are often referred to, but the knowledge of them is so incomplete due to their inaccessibility that a brief exposition of them may be of interest (1).

(1) A bibliography of BUBNOV's mathematical writings is as follows (those used by the present writer are indicated by capital letters and are cited thus throughout the article) :

A. *Gerberti postea Silvestri II papae Opera Mathematica* (972-1003), Berolini, 1899.

B. " Podlinnoe sochinenie Gerberta ob abakie ili sistema elementarnoĭ arithmetiki klassicheskoĭ drevnosti," *Kievskīĭa universitetskīĭa izviestīĭa*, 45, nos. 7, 10, 11; 49, nos. 2, 3, 5, 6, 7, 9, 10; 50, nos. 6, 8, 1905-1910. Also published separately at Kiev, 1911. (" The authentic writing of GERBERT on the abacus, or the system of elementary arithmetic of classical antiquity.")

Arithmeticheskaĭa samostoĭatelnost europeiskoĭ kultury, Kiev, 1908. Translated into German with the title,

C. *Arithmetische Selbständigkeit der europäischen Kultur*, Berlin, 1914 (translation by J. LEZIUS.)

D. " Abak i Boetsiĭ. Lotaringskiĭ naoochnyĭ podlog XI. v.", *Zhurnal ministerstva narodnago prosvieshchenīĭa*, novaĭa seriĭa, 7, 8, 16, 17, 19, 20, 21, 1907-1909. Published separately at Petrograd, 1915. (" The Abacus and Boethius. A Lotharingian falsification of the 11th century.")

Proiskhozhdenie i istorīĭa nashikh tsifr, Kiev, 1908. *(The Origin and History of our Numerals.)*

E. " Proiskhozhdenie sovremennago schisleniĭa," *Kievskīĭa universitetskīĭa izviestīĭa*, 1913, no. 6. (" The Origin of the present method of representing numbers.")

Abak-kolybel sovremennoĭ arithmetiki, Kiev, 1912. *(The Abacus-cradle of our present arithmetic.)*

Zabytaĭa arithmetika klassicheskoĭ drevnosti, Kiev, 1916. *(The forgotten Arithmetic of Classical Antiquity.)*

F. " Postanak savremenog načina pisanja brojkī i cifara," *Rad. Jugoslavenske Akademije Znanosti i Umjetnosti, Razreda Matematičko-Prirodoslovnoga*, Zagreb,

XUM

BUBNOV denies the Hindu origin of our present numerals, contending that the fundamental elements of our present system were known in classical antiquity, and that our debt is to the Greeks, not the Hindus. These elements are :

1. Fixing of the method of writing the first nine numbers. The Greeks had twenty-seven symbols, namely the letters of the counting alphabet, the first nine (α—θ), the tens, and the nine hundreds, which could have place value, but whose disadvantage lay in their similarity to the Greek letters.

2. Place value. Greek and Roman numerals usually had a value independent of position.

3. The necessary tenth number.

4. Representation of the numbers by symbols unlike an alphabet. This is distinctive, but not fundamental. These elements developed by a slow process, lasting hundreds if not thousands of years, and took place among different peoples and different cultures so that special individuals cannot lay claim to their origin. However, the Greeks were familiar with all of these fundamental elements, even to the idea of a zero in the form of a blank stone or counter for reckoning.

Actually, the present method of writing numbers results from a transfer of the instrumental arithmetic of the abacus to writing. Both Greeks and Romans, like the abacists of the 10th-12th

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vol. 230, pp. 227-258, 1925. (" The origin of the present method of representing numbers.") An abstract of this in German in

G. *Izvještća o raspravama* of the same Academy, 1924, pp. 102-116, with the title " Über den Ursprung der heutigen Zahlendarstellung."

According to his own announcement, BUBNOV has written another work dealing with the same general topics, but I have been unable to find place or date of publication :

Abak i Araby. (The Abacus and the Arabs.)

Some brief notices of BUBNOV's work will be found in *Jahrbuch über die Fortschritte der Mathematik*, 30, p. 3, vol. 36, p. 51, vol. 38, p. 62, vol. 39, p. 53, vol. 45, pp. 64, 1214; JULIUS RUSKA, " Zur ältesten arabischen Algebra und Rechenkunst," *Stzb. d. Heidelberg. Ak. d. wiss., Phil.-hist. Kl.*, 1917, abt. 2; RUSKA in *Islam*, X, 1920; JOHANNES TROPFKE, *Geschichte der Elementar-Mathematik*, vol. 4, Berlin, 1923, 2° Aufl.; J. MILLÀS VALLICROSA, *Assaig d'història de les idees físiques i matemàtiques a la Catalunya medieval*, vol. I, Barcelona, 1931. *Estudis Universitaris Catalans*. Sèrie monogràfica, I (deals chiefly with the ideas in A.)

At present BUBNOV is engaged upon an edition and translation into French of the Works of GERBERT, in collaboration with JEAN PORCHER, to appear in the series, *Les classiques de l'histoire de France au moyen age*.

centuries, employed two methods for the representation of numbers, one on the abacus, the other on papyrus or parchment. The latter was used for fixing the results obtained on the abacus, but without a written zero the abacus symbols could not be used here so that it was necessary to utilize numeral symbols not requiring a zero. Such a transfer, then, became possible upon the appearance of suitable writing materials instead of the expensive papyrus and parchment, and upon the substitution of the written symbol for zero for the blank reckoning counter. A cheap writing material was early found in India in the form of palm leaves, and the zero was employed by the eighth century. In Europe, however, papyrus and parchment continued in use until the appearance of paper in the 13th-14th centuries and hence the transfer to written arithmetic was delayed.

The abacus, which was well known to the Greeks, as literary and archaeological evidence proves, on its appearance in western Europe in the 10th century possessed in instrumental form all of the above-mentioned elements of representing numbers. Place value was a feature of the abacus and was constantly employed in arithmetical operations, but was not employed outside of the abacus until the 13th century, due to the failure of the abacists to understand the theory of the zero which they actually used in practice. The counters of the abacus were strung on a cord when not in use so that they would not be lost and thus each counter, whether blank or with a symbol thereon, had a hole in it. These blank counters with holes in the centers were put in blank columns (for convenience, not of necessity) and from them the zero was derived, being simply the written arithmetical sign for this blank counter, or rather the hole. (2) Although the earliest example of its use comes from the Hindus in the 8th century A.D., there is no proof that the sign was not known outside India before this time (3). So, with the abacists if $\overline{9}\,\overline{|}\,\overline{2}\,\overline{|} = 902$ were written or represented carelessly, the result

(2) Blank counters sometimes had other functions, such as designating numbers to be multiplied in figures of several digits.

(3) In support of BUBNOV's theory is the recent notice of the appearance of "Arabic" numerals including the zero in Indo-China in the 7th century A.D. G. COEDÈS, "A propos de l'origine des chiffres arabes," *Bulletin of the School of Oriental Studies* (University of London), 6, pp. 323-328, 1931.

might be |9 |2| = 92, but |9 ⊙ 2| solved the difficulty. The abacists called this zero *sipos*, a corrupt form of the Greek *psephos* (ψῆφος), meaning stone or reckoning counter, rather than *ṣifr*, the Arabic word for zero, but it was used only on the abacus. Even as late as A.D. 1200, an abacist could write 12 or 31, but could not write 10, 20, 30, etc., writing instead X, XX, XXX.

The fingers on the hands were certainly the first means of counting so that it is not strange that a system based on tens should appear among widely scattered peoples. But before the development of an arithmetical system based on tens, one based on fives arose, thus the first five numbers were developed first and those from 6-9 later. Since speed was demanded in calculating, symbols satisfying this requirement were developed by the use of little lines bound together (except the 4). So, the Romans made a small horizontal mark, for 1 *uncia*, two horizontal marks for 2 *unciae*, which, in rapid writing, became , a symbol closely resembling our 2; three horizontal lines resulted in , 3; while the sign for 4 came from four lines in a cross or , (such a figure was found in Bactria in Central Asia.) For 5, the abacists wrote , , , a derivation from a hieroglyphic representation of the hand, five lines thus : , whereas the Arabs wrote for five. The numbers 6-9, of later development, are nothing but diacritical signs, thus 6, , indicates that it is one more than 5; the symbol for 7, , , that it is two more than five; 8 is a closed 3; while 9 being four more than 5 resembles a four as written by the abacists of the 10th-12th centuries.

The symbols used by the western Arabs were similar to those of the Hindus and those of the Latin abacists, but unlike those of the eastern Arabs, and this can be explained only by an independent development from a common origin. It appears, then, that the western Arabs had come under the influence of abacists

of the Graeco-Roman tradition, in fact, the Arabs adopted the Latin abacus numerals from the necessity for speedy writing, and not *vice versa*.

True, there is no direct evidence of the symbols used on the counters of the abacus in classical times, for the counters were made of wood (4) or some such material and none have survived. Calculating was also performed on tablets of wax so that the calculations could be easily erased, and none were left for posterity.

On etymological grounds also BUBNOV denies the Hindu-Arabic origin of our numerals. In manuscripts of the 11th century, and possibly of the end of the 10th century, are found strange names for the symbols used on the abacus, *i.e. igin, andras, ormis, arbas, quimas, caltis, zenis, zemenias* or *temenias, celentis*, words unknown to the Hindus, and meaning 1, 2, 3, 4, 5, 6, 7, 8, 9. The words for 1, 2, 3, 6, 7, and 9 belong to the languages of peoples of Ural-Altaic origin; thus, *igin* is related to Hungarian *ik, ekky*, and to an Ugro-Finnish dialect of Siberia, *ögy, egid; ormis*, to the Hungarian *horom, harom; caltis*, to the Turkish *alti; zenis*, to the Turkish *sekis*, or *senknis* without the " k "; *celentis* (pronounced *kelentis*), to the Hungarian *kilencz*. Only the names for 4, 5, and 8 are of Semitic origin (5). So, *arbas* is related to Babylonian *irban*, Hebrew *arbaah*, Arabic *arbaa; quimas* is a corrupt form of Babylonian *hamšu*, Hebrew *hamš*, Arabic *hamše;* while *zemenias (temenias)* is related to Babylonian *samanu*, Arabic *temania*. *Sipos* was a corruption of the Greek *psephos*, and was used by the eleventh century abacists, but could not have been derived from *şifr*, which was not in use until the 12th century, and then not by the abacists (6). Such a mixture could have occurred

(4) D. E. SMITH, *History of Mathematics*, II, 165, New York, 1925, states that they were of bronze, stone, ivory and colored glass.

(5) C., pp. 59 ff.; G., pp. 111-112; F., pp. 250-251. On the other hand, RUSKA, *op. cit.*, p. 88, criticising BUBNOV, insists that all these names, including *sipos*, are corrupt forms of Arabic, thus :

Latin	igin	andras	ormis	arbas	quimas	calcis	zenis	temenias
Arabic	wāḥid	iṯnān	ṯalāṯat	arba'at	ḫamsat	sittat	sab'at	ṯamānijat
Latin	celentis	sipos.						
Arabic	tis'at	ṣifr.						

(6) The blank counter was called *rotula supervacua* by some abacists (A., p. 257, ll. 13-14), and BUBNOV believes that this as well as the Indian *sūnya* and the Arabic *şifr*, which had the same meaning, probably was a translation of an attri-

in Mesopotamia before the Christian era, if one accepts the fact that the peoples there were subjected to Semitic (Babylonian) domination. If our numerals had originated in India, the names would result from a mixture of Indo-European word roots and Semitic (Arabic). Our numerals and these strange names originated in central Asia and from there spread both to India and to western Asia where the Greeks became acquainted with them and through the Greeks they found a place on the abacus (7).

These symbols are the ones GERBERT had cut on the horn counters which he used on the abacus in his teaching. Not that they were necessary for the use of the abacus, as blank counters could be utilized, or Greek symbols or Roman numerals, but they proved convenient (8). However, the treatises describing the use of the abacus, of necessity, used Roman notation because, without the abacus, there was no method of writing the zero, the use of which was understood on the abacus (by means of the blank column or blank counter), but which the mediaeval abacists were unable to express in writing.

Both abacus and symbols were inherited from classical antiquity and therefore GERBERT did not bring them from the Arabs, in fact, the abacus was non-existent among the Spanish Arabs. Moreover, the calculating method of the abacus was foreign to both Hindus and Arabs (9).

The knowledge of the abacus was widespread, for there are references to it independent of GERBERT, *i.e.*, ABBO of Fleury

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butive adjective used with *psephos*, and that *super vacua* was descriptive of the function of this *rotula*.

(7) For notation unconnected with the abacus the Greeks employed the twenty-seven symbols of their counting alphabet, which were similar to letters. With the Romans, the similarity of their numerals I, V, X, L, C, D, M, to letters was due to their development from symbols which had nothing in common with letters.

(8) Roman numerals were confined to the designation of the value of the columns, and were not used for calculating on the column abacus, due to the fact that most of the numbers occupied more than one place. At one point (A., p. 381, n. 23) BUBNOV suggests that the *novem numero notas omnem numerum significantes* mentioned by RICHER (III, 54) in his description of GERBERT's abacus may be Indian, called also Arabic. This led a reviewer of his work in the *English Historical Review*, XV, 613, 1900, to state that BUBNOV "admits that Gerbert borrowed the nine digits from the Arabs." Whatever BUBNOV's ideas in this earlier work, he has since been emphatically opposed to any such notion.

(9) C., p. 90.

(who called himself *doctor abaci*) (10), WALTER of Speyer (11), HERIGER of Lobbes, NOTKER and WAZZO of Liège, and an unknown abacist of the end of the tenth century (12), and none of them refer to GERBERT as *the* teacher of the abacus, nor to anything Arabic about it. In the tenth century, then, there existed a brief textbook on the use of the abacus which has not survived in its original form, and which relied solely on classical ideas. The simplest form of this book is to be found in the rules for the use of the abacus written by GERBERT (13) about the year 980 A.D. In the prefatory letter GERBERT states that several *lustra* (five year periods) had passed since he had had any practice in its use, or any book on the subject. Hence he must have studied the book *before* going to Spain in 967 (14) where he remained for three years. The rules which he writes out he does so from memory (15), with a resultant conciseness which

(10) It is not clear why SMITH, *op. cit.*, I, 190, 195, states, without proof, that ABBO taught GERBERT, and at Aurillac *(sic)*. They were, in fact, rivals, and GERBERT seems to have referred to him contemptuously as a *philosophus sine litteris* who should not be attempting to *teach* the terminology of the abacus, since he was only *learning* (A., p. 7). Later, remarks of the same tenor were directed against him (A., pp. 23-24.)

(11) BUBNOV translates, *metae* used by WALTER as " columns " (A., p. 204, n. 2), and similarly PERSIUS (I, 131). As to the latter, he states that PERSIUS was acquainted with a kind of abacus where the columns *(metae)* were drawn on a board covered with a special kind of sand *(secto in pulvere)* (F., p. 235). On this question see SOLOMON GANDZ, " The Origin of the Ghubār Numerals, or the Arabian Abacus and the Articuli," *Isis*, XVI, pp. 398 ff., 1931.

(12) Printed in A., pp. 225 ff. To these BUBNOV should have added BYRHTFERT, monk of Ramsey, who reproduces rules for the operations on the abacus which, according to his own words, were taught him by ABBO of Fleury. See S. J. CRAWFORD (ed.), *Byrhtfert's Manual*, I, 232-234, 1929, *Early English Text Society*, vol. 133. BUBNOV calls especial attention to the great interest taken by men of Liège in the abacus, to wit, HERIGER, NOTKER, ADELBOLD, WAZZO, FRANCO and RADULF (D., p. 1, n. 1.)

(13) Printed in A., pp. 8 ff. This is the oldest Latin discussion of the abacus which has survived.

(14) In A., p. 6, n. 5, BUBNOV declares that it seems very likely that GERBERT studied this *Anonymous* in the Spanish March as well as at Aurillac, but in later writings (C., pp. 33, 244; E., p. 32) he is very emphatic in stating that GERBERT studied it *before* going to Spain. However, MILLÀS VALLICROSA, *op. cit.*, p. 113, although acquainted with BUBNOV's later work, cites only BUBNOV's earlier view, apparently trying to prove that GERBERT gained *all* his mathematical knowledge in Spain.

(15) BUBNOV now believes that GERBERT wrote only one work on the abacus, and that the letter which he published in A., pp. 23-24 as a *Fragmentum de norma*

dissatisfied other mathematicians of the period, who promptly improved his work by rules taken from the original textbook (16). This Latin textbook BUBNOV has reconstructed and published with the title *Anonymus Bubnovianus* (17). Neither in it nor in GERBERT's rules jotted down from memory is there the slightest trace of Arabic influence (18). It was written in good Latin and reveals a sure knowledge of the terminology and rules of the abacus, giving only practical rules without examples. Was this text possibly scratched on the back of a metal abacus and so survived until the 9th or 10th century? In other branches of knowledge in which the Arabs acted as middlemen in the transmission of learning to Latin Europe, Arabic terminology was substituted for the original, but the works on the abacus are wanting in this respect, keeping only to classical expressions (19).

Of an Arabic origin of the abacus we hear nothing at all from the abacists in the 10th-12th centuries. If the abacus rested on Arabic sources how can one account for the use of Roman and Greek as well as the ghubār numerals in connection with the abacus (20)? RICHER sees nothing new in the abacus that GERBERT could have learned from the Arabs in Spain, and GERBERT himself writes of the necessity of studying what the ancients *(majorum, veteribus)* teach on the subject (21).

The word abacus is derived from the Greek ἄβαξ, ἀβάκιον and is *not* a Semitic word so that it can by no means be derived from Hebrew. It means board, not sand or dust. The fact

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abaci was not an introduction to another work on multiplication and division on the abacus. See B., p. 92.

(16) About the year 1000 appeared a commentary on GERBERT's rules, printed in A., pp. 246 ff. This date is determined by words on p. 250, 22-23, which BUBNOV now reads *etiam honorum gradibus*, referring to GERBERT's elevation to the papacy, instead of *horum gradibus* as printed. See B., p. 2, and n. 4.

(17) In B.

(18) BUBNOV fails to find evidence of Arabic science in any of GERBERT's works. See F., p. 240. Earlier, BUBNOV hesitated over the work on the astrolabe, A., pp. 114 ff; E., pp. 62-63.

(19) Latin terminology is used to designate the numerals, as *binarius, ternarius,* or *duo, tres,* etc.

(20) The reference of the 14th century MAXIMUS PLANUDES to the moving of counters in the Hindu fashion shows the influence of the abacus, for Hindu arithmetic was unacquainted with any sort of counters.

(21) A., pp. 7, 24.

that the Hebrew equivalent of *pulvis eruditus* may appear in the Talmud shows the influence of Greece and Rome.

GERBERT's requests for a book *de multiplicatione et divisione numerorum* written by a certain *Joseph Ispanus* or *sapiens* (22) have misled many persons into believing that this had some connection with GERBERT's writing on the abacus, and that therefore the latter was based upon Arabic learning. Actually, GERBERT appears unacquainted with the contents of the work (23), and, moreover, these requests were made in the year 984 whereas his writing on the abacus was composed by 983 at the very latest.

Much confusion regarding the introduction of our numerals into western Europe has been caused by the " geometries " which have come down to us under the name of BOETHIUS. According to excellent evidence BOETHIUS was the author of a geometry which was really a translation of EUCLID, but it has survived only in very garbled form. In the 8th century, or possibly the 7th, appeared a geometry in five books to which the name of BOETHIUS was attached (24), but whose real author is unknown. In the 11th century an anonymous person in Lotharingia composed a geometry in two books to which he attached BOETHIUS' name, and in which he inserted arithmetical material (25). Since, in the common opinion of the period, the abacus had a close connection with geometry (26) this falsifier attempted to strengthen the belief in the abacus as a classical heritage by references to BOETHIUS, even to PYTHAGORAS, as inventor. ARCHITAS, a Greek from Tarentum, pupil of PYTHAGORAS, is also mentioned among those responsible for making Greek knowledge available to the Latins. But, not only did he live much too early for this, but he lacked a knowledge of Latin, and the " ARCHITAS " was really GERBERT.

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(22) Epp. 17 and 25, ed. Havet. This JOSEPH still remains unknown.

(23) However, it certainly dealt with the abacus. See E., p. 59.

(24) Outlined in A., pp. 182 ff.

(25) Ed. G. FRIEDLEIN, Lipsiae, 1867. The falsifier used the collection of writings on the abacus assembled for, or dedicated to OTTO III (A., pp. 294-296). PAUL TANNERY, " Une correspondance d'Écolatres d. XI^e siècle," *Comptes rendus de l'Académie des Inscriptions et Belles-Lettres*, XXV, 501, 1897, states that this two-book geometry was written in the second half of the 11th century in Italy.

(26) RICHER, III, 54, *In geometria vero non minor in docendo labor expensus est. Cujus introductioni abacum*. WALTER of Speyer, in A., p. 204; Commentary on GERBERT's Rules (A., p. 250, I, 4), *Vocatur ergo abacus mensa geometricalis*.

XUM

Although quite incorrect, these claims do prove a classical tradition for the abacus, for who in the middle of the 11th century would have dared to claim classical ancestry for it if it had been learned from the Arabs at the end of the 10th century? It is in the manuscripts of this 11th century pseudo-BOETHIUS geometry in two books that the symbols for our numerals appear, hence the conclusion accepted by many scholars that BOETHIUS played a part in the introduction of these numerals into Latin Europe. BOETHIUS may have known the symbols, and according to BUBNOV's theory there is no reason why he should not have, but he was *not* the author of any surviving geometries circulating under his name so that conclusions as to his part in the transmission of the numerals based on their contents are worthless.

AUTHOR'S NOTE.—It must have been observed that BUBNOV nowhere has given consideration to the presence of the ghubār numerals in two manuscripts from northern Spain, the famous Codex Albeldensis and Codex Æmilianensis (27), nor to the statement of their composer of the debt to the Indians for the nine numerals (28). On the basis of these MSS. Professor JOHN BURNAM evolved the theory that the prototype of these MSS. was to be sought in the most outstanding monastery of Catalonia, Ripoll, where, according to a now prevalent belief, GERBERT studied during his three years in the Spanish March (29), and that here GERBERT became acquainted with the numerals (30). Moreover, of importance for this discussion, BURNAM believed that the numerals were introduced into Barcelona from the east and from there spread into all parts of Spain so that both Arabic and Latin Spain received them from this source (31).

Moreover, these same two MSS. contain concise rules for

(27) Now MSS. Escorialenses I. d. 2. and I.d.1., dated 976 and 992.

(28) JOHN BURNAM, "A group of Spanish manuscripts," *Bulletin Hispanique*, XXII, 229, 1920.

(29) First suggested by RUDOLF BEER, "Die Handschriften des Klosters Santa Maria de Ripoll", I, *Sitzb. d. Ak. d. Wiss. in Wien*, phil.-hist. Kl, CLV, 1907.

(30) In further support of the hypothesis that the prototype was at Ripoll comes the information that these MSS. contain councils of Catalan dioceses which are not included in other celebrated MSS. of councils, and that Ripoll possessed ancient MSS. of councils, at least one of which dated from the beginning of the 10th century. See MILLÀS VALLICROSA, *op. cit.*, 245.

(31) BURNAM, *op. cit.*, p. 232. SMITH, *op. cit.*, II, 75-76, seems to accept this theory.

multiplication on the abacus very similar to GERBERT's and ABBO's. Thus, contrary to BUBNOV's revised idea as to the period in which GERBERT became familiar with such rules, it seems very possible that he came into contact with the rules in Spain, and at Ripoll if BURNAM is right, or else *via* Spain. The identification of these rules with the work of *Joseph Ispanus* (31*a*) is now tempting, especially because a copy of his work was left at Aurillac, where GERBERT spent his youth, by Abbot *Warnerius* (31*b*) (presumably *Guarinus*, abbot of Cuxa, who was in close contact with the Spanish March), and because Bishop MIRO († 984) of Gerona was also acquainted with the work (31*c*). I have been unable to find any discussion of the rules in these MSS. in connection with GERBERT (31*d*) so that it seems worth while to reproduce them here. They occur on fol. 12*v* of MS. d. I. 2. (Albeldensis) and are preceded by an excerpt from ISIDORE's *Etymologiae* (III, c. 4, on the value of knowing numbers), and the multiplication table.

Item quando suputaberis singularem numerum per decenum numerum ; dabis unicuique digito decem. et omni articulo centum : Quando suputaberis d (31e) singularem numerum per centenum numerum; dabis unicuique digito centum. et omni articulo T [mille] : Quando subputaberis singularem numerum per millenum numerum ; dabis unicuique digito T. et omni articulo x̄ a [decem milia] :

Item quando subputaberis decenum numerum per decenum numerum ; dabis unicuique digito centum ; et omni articulo T : Quando subputaveris decenum numerum per centenum numerum ; dabis unicuique digito T. et omni articulo x̄ a

Quando subputaberis decenum numerum per T numerum : dabis unicuique digito x̄ a. et omni articulo ; centum milia.

Item quando subputaberis centenum numerum per centenum numerum : dabis unicuique digito ; x̄ a. et omni articulo. c̄ a. Quando

(31*a*) See p. 8, *supra*.

(31*b*) *Lettres de Gerbert*, ep. 17.

(31*c*) Ep. 25.

(31*d*) Except the remark of J. M. BURNAM, " Les multiplications ressemblent un peu au text de Boethius, *Ars Geometria*... pp. 398-99." See his *Palaeographia iberica*, II, 89, Paris, 1920. The latest edition of JOHANNES TROPFKE, *Geschichte der Elementar-Mathematik*, I[3], Berlin, 1930, makes no reference to them.

(31*e*) Apparently the copyist here began to write the rules for " decenum," but changed his mind. Did he have before him two sets of rules? See GERBERT's rule 2, BUBNOV, A., p. 9.

XUM

subputabêris centenum numerum per millenum numerum dabis unicuique digito c̄ a. et omni articulo T milia:

ITEM Quando subputaberis millenum numerum per millenum numerum dabis unicuique digito. T milia. et omni articulo x̄ milies:

Then follows the material on the numerals described in the preceding paragraph (31*f*). Codex Æmilianensis, which is a twin copy of the Albeldensis, required sixteen years for its completion (31*g*) so that it seems probable that these rules were copied into the Albeldensis (completed in 976) before GERBERT's arrival in Spain in 967. Hence, GERBERT's rules are *not* the oldest Latin discussion of the rules of the abacus (31*h*).

There are others, independent of BUBNOV, who are dissatisfied with the Hindu-Arabic theory of the origin of our present system of numeration, especially Sir G. R. KAYE (32) and Baron CARRA DE VAUX (33). Both call attention to the fact that confusion has been caused by a misinterpretation of the words *hindi* and *hindasi* in connection with numerals. They do not mean Hindu, but refer to numeration and mensuration. KAYE discounts the ingenuity of the Hindus in the mathematical field, and believes "the notation was introduced into India, as it was into Europe, from a right-to-left script" (34). CARRA DE VAUX argues for their origin in the neopythagorean schools of the Greek world from whence they passed to the Latin world and to Persia. It was through the Persians that the Hindus became acquainted with the numerals, and it was the Persians who taught the Arabs and the Byzantines.

The theory of Professor SOLOMON GANDZ bears some resemblance to that of BUBNOV, although he does not deal with the problem of ultimate origin (35). He believes the Eastern Arabs adopted numerals from the Hindus, but the Western Arabs adopted the

(31*f*) Facsimile of this folio, plate XXIII in BURNAM, *op. cit.*, with transcription on pp. 91-92.

(31*g*) P. GUILLERMO ANTOLIN, "El codice emilianense de la biblioteca de El Escorial," *Ciudad de Dios*, LXXII, 192, 1907.

(31*h*) Se n. 13 *supra*. The material on these rules was added while this article was in proof.

(32) "Indian mathematics," *Isis*, II, 326-256, 1914-1919.

(33) "Sur l'origine de nos chiffres," *Scientia*, XXI, 273-283, 1917.

(34) P. 246.

(35) *Op. cit.*

Roman abacus numerals which they found in Spain, and called ghubār, and that Europe re-learned them from the Arabs (36).

Hence, it will be seen that there is a growing tendency to arrive at conclusions similar to those of BUBNOV, although approached from different viewpoints.

I have wondered why RICHER and BERNELINUS are the only ones cited from GERBERT's circle as proof that GERBERT knew the so-called Hindu-Arabic numerals. Even more convincing appear the words in the Commentary on GERBERT's Rules written in 999-1000 (37). *Sunt namque novem insignes numerorum caracteres, qui propriis insignes notulis certisque distributi intervallis designant quandam potentem efficaciam suae mirabilis operationis. Intervalla autem, in quibus distribuuntur, dicimus sedes bonorum (horum?) numerorum, qui in hac abaci regula secundum geometricam habitudinem sic proportionaliter ordinati continentur, ut, juxta numerum supradictorum novem caracterum novies ternis alternatim distinctis terminis, aequa in omnibus proportio servetur* (38)... *Notandum etiam, quod adhibentur praeterea in compositis multiplicationibus cum novem praedictis caracteribus duae rotulae supervacuae ad observandas tantum metas multiplicatorum et multiplicandorum, quando scilicet in diversis terminis plures supra et infra disponuntur numeri inter se conferendi* (39). Did the author of this Commentary have at hand a copy of RICHER? In connection with GERBERT's work on the abacus he mentions *quantoque sudore idem summus et incomparabilis vir in his invigilaverit* (40), while RICHER writes *In mathesis vero quantus sudor expensus sit* (III, 48) (41).

It is, perhaps, not out of place here to call attention to a statement repeated so often by BUBNOV in the course of his *Opera Gerberti* (A.) as to be misleading, although he repudiated it before the completion of publication, but it was then too late to change the earlier passages. Thus, the manuscripts of *praeclarissima quoque figurarum geometriae*

(36) Professor GANDZ's statement (p. 414) that " there is no direct evidence in favor of his (Gerbert) being in touch with Arabian culture " should be modified in view of the recent publication of Latin translations of Arabic works on the astrolabe, made from MS. Ripoll 225, s. X by MILLÀS VALLICROSA, *op. cit.*

(37) Printed in A., pp. 246 ff. See n. 16 *supra*.

(38) A., p. 246, I, 2.

(39) A., p. 257, II, 6.

(40) A., p. 250, I, 5.

(41) Cf. WILLIAM OF MALMESBURY, II, 167, *sudantibus abacistis*, in A., p. 387.

which GERBERT found in Italy (ep. 8) BUBNOV at first interpreted to be the 13, 14, or 15 books of the Elements of EUCLID translated by BOETHIUS (42), but further study of the manuscripts of the Roman agrimensores convinced him that, instead, GERBERT found one of these manuscripts, at the beginning of which was the pseudo-BOETHIUS Geometry in 5 books. MS. Naples Bibl. Borbonica V A 13, s. X (middle) most nearly conforms to the analysis of the contents of GERBERT's manuscript made by BUBNOV (43). It was *after* the discovery of this manuscript that GERBERT composed his geometry, not before, as BUBNOV at first believed (44), and it was a copy of this manuscript of the agrimensores which GERBERT sent to ADELBOLD, later bishop of Utrecht (45).

Columbus, Ohio. HARRIET PRATT LATTIN.

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(42) A., p. 100 ,nn. 6 and 8. Also, p. X; p. 51, n. 1; pp. 161-162; p. 180 and n. 1. MILLÀS VALLICROSA, *op. cit.*, p. 142, continues to follow the error rather than BUBNOV's corrected statement.

(43) It has been corrected by some learned hand before the year 1004 (when MS. Bern Bong. 87 was written at Luxeuil from a copy of it) apparently that of GERBERT or his circle, possibly using for the corrections the famous MS. Arcerianus (Wolfenbüttel 2403, Aug. f. 36, 23, s. VI). If so, the Arcerianus must have been at Bobbio in the 10th century, although this is generally denied. Such, however, is the opinion of CARL THULIN, *Zur Überlieferungsgeschichte des Corpus Agrimensorum. Exzerptenhandschriften* und *Kompendien*, Göteburg, 1911, pp. 4-5, 10-11; *Corpus Agrimensorum Romanorum*, Lipsiae (Teubner), 1913, vol. I, fasc. I, p. III. BUBNOV nowhere takes cognizance of the work of THULIN.

(44) A., p. 46, n. 1. Corrected, p. 556; D., p. 239; C., p. 36.

(45) According to BUBNOV, ADELBOLD or his pupils attached GERBERT's name to the contents and this work circulated as a pseudo-GERBERT geometry. Against this, see THULIN, *Zur Überlieferungsgeschichte*.

Notes and Correspondence

Annual Meeting of the American Council of Learned Societies, January 29, 30, 1932 (Summary of Proceedings). — The fourteenth meeting of the American Council of Learned Societies, being its thirteenth annual meeting, was held in Washington on January 29-30, 1932. The 18 constituent societies were represented by 44 delegates and secretaries.

The Permanent Secretary, Dr. WALDO G. LELAND, announces the appointment, on part-time, of Mr. JOHN MARSHALL of Cambridge, Mass., as editor, bringing the strength of the executive staff to seven full-time and two part-time positions.

The total budget of the Council, for 1932, including fellowships and grants-in-aid, the *Dictionary of American Biography*, and other specially financed projects, amounts to approximately $ 370.000. Provision is made for the following undertakings :

In the field of *Bibliography :* the continuation under the auspices of the Bibliographical Society of America of JOSEPH SABIN's *Dictionary of Books Relating to America* ; assistance through the American Antiquarian Society to the publication of the 12th volume, being the last one, of CHARLES EVANS' *American Bibliography* ; the completion by the American Historical Association of its *Bibliography of American Travel* ; the completion by the same Association of a cumulative index to the successive volumes, 1906-1930, of its annual bibliography *Writings on American History* ; assistance to Professor LOUIS C. KARPINSKI of the University of Michigan for preliminary work on his proposed *Bibliography of Printed Maps of America* ; and completion of a Catalogue of Current Bibliographies of the Humanities and Social Sciences.

In the domain of *Archaeology :* assistance to the excavation of Samaria, a project of Harvard University and the Palestine Exploration Fund under the direction of Professors KIRSOPP LAKE and ROBERT P. BLAKE of Harvard University ; assistance to the first year's campaign of the excavation of Antioch in Syria, a project of the Department of Art and Archaeology of Princeton University, in cooperation with the French Service of Antiquities, and with the Baltimore and Worcester Museums ; assistance to the publication, by Professor DAVID M. ROBINSON of Johns

XUM

Hopkins University, of the results of his excavations at Olynthus in Macedonia; assistance to the excavation of certain prehistoric caves near Haifa, in Palestine, by the American School of Prehistoric Research.

In the field of *Art:* preparation and publication of American fascicles of the international Corpus of Ancient Vases, sponsored by the International Union of Academies; assistance to the publication of Professor RICHARD OFFNER's Corpus of Florentine Paintings, sponsored by New York University.

In the field of *Musicology:* assistance to the publication of the Corpus of Medieval Songs, of Professor JEAN BECK of the University of Pennsylvania; assistance to the publication of the Corpus of Hebrew Oriental Melodies, of Professor A. Z. IDELSOHN of Hebrew Union College.

In the field of *Philology* and *Linguistics:* compilation of an Index Verborum to the Letters of CICERO, under the direction of Professor W. A. OLDFATHER of the University of Illinois; participation by American scholars in the Anglo-American Dictionary of Medieval British Latin, and in the international Dictionary of Medieval Latin; an edition of the Commentaries on VERGIL, by SERVIUS, a project of the Mediaeval Academy of America; a Glossary of Medieval Terms of Business, also a project of the Mediaeval Academy; assistance to the New Dictionary of Middle English, sponsored by the Modern Language Association and executed at the University of Michigan; the publication of a concordance to the plays of BEN JONSON, compiled by Mr. CHARLES CRAWFORD and sponsored by the Modern Language Association; the continuation, under the direction of Professor HANS KURATH, of the study of New England dialects, as the first part of the Council's projected Linguistic Atlas of the United States and Canada; the continuation of research and publication in Native American Languages, a project of the Council directed by Professors FRANZ BOAS, EDWARD SAPIR, and LEONARD BLOOMFIELD.

In the field of *Palaeography:* continuation of the preparation of a *Palaeographical Guide to Latin MSS. prior* to 800 A.D., by E. A. LOWE, of the Carnegie Institution of Washington.

In the field of *History:* The completion of studies in the organization and functioning of departments of the English Government between 1327 and 1336, sponsored by the Mediaeval Academy; the continuation of studies in the history of Anglo-Papal relations prior to the Protestant revolution, also sponsored by the Mediaeval Academy; the continuation of the *Dictionary of American Biography*, sponsored by the Council.

In the *History of Thought:* research in the earliest history of Greek thought, by Professor WILLIAM A. HEIDEL; catalogue of the manuscript Latin translations of ARISTOTLE, preliminary to editing a corpus of

medieval Aristotelian texts, a project of the Union of Academies ; preliminary work on editions of the Arabic, Hebrew and Latin versions of the Aristotelian Commentaries of AVERROES, a project of the Mediaeval Academy contributory to the international project of the Union of Academies ; a Documentary History of Primitivism and Anti-Primitivism, by Professors ARTHUR O. LOVEJOY, GILBERT CHINARD, and GEORGE BOAS, of Johns Hopkins.

In the *History of Law :* edition of documentary materials bearing upon the application of customary law in the Philippine Islands, contributory to an international study of Indonesian Customary Law, sponsored by the Union of Academies.

In *Oriental Studies :* continuation of a Survey of Materials and Facilities for Chinese Studies, by CHARLES S. GARDNER, under the auspices of the Council ; publication of the second annual Bulletin on the Progress of Chinese Studies in the United States ; participation with Harvard-Yenching Institute in the organization of a *Summer Seminar in Far Eastern Studies*, to be held during the Harvard Summer School in July-August, 1932 ; publication of the first of a series of annual volumes of selected American studies in the field of Sinology ; participation in the eventual organization of an American School of Indic and Iranian Studies in India.

Officers for 1932 were elected as follows : chairman, EDWARD C. ARMSTRONG, Princeton University ; vice-chairman, J. FRANKLIN JAMESON, Library of Congress ; secretary-treasurer, WILLIAM E. LINGELBACH, University of Pennsylvania ; members of the Executive Committee, in addition to the officers, ALFRED V. KIDDER, Carnegie Institution of Washington ; ROBERT P. BLAKE, Harvard University ; members of the Advisory Board, JOSEPH P. CHAMBERLAIN, Columbia University ; EDWIN F. GAY, Harvard University ; WILLIAM H. HAMMOND, Library of Congress.

Upon invitation of the delegates of the American Philosophical Society, the Council voted to hold the next annual meeting in Philadelphia on January 27, 28, 1933.

Personalia. — In order to increase the speed of publication, all the notes concerning the teaching of the History of Science, obituaries, commemorations, anniversaries, in short all the " news " should be addressed directly to the Managing Editor, Mr L. GUINET, 11, place Général Meiser, Brussels 3, Belgium.

Carl Horber (1882-1931). The great Swiss economist and philanthropist CARL HORBER died prematurely at Zurich on 7th August 1931

after a long illness. The journal *Isis* and its Editor lose in him their best and most generous friend. A few years ago when the Editor was asking himself how the publication could be continued and when the financial burden was weighing more heavily than ever upon his shoulders, Mr. HORBER, who was then visiting the United States with his wife, came to see him and spontaneously offered his help in the most generous and the simplest manner.

Mr. HORBER was a man of action rather than a man of letters and had but little time for the writing of books. Yet we owe to him a most remarkable discussion of political affairs in general, with special application to his beloved country Switzerland, entitled *Die schweizerische Politik* (Bern, 1928, *Isis*, 13, 569), and at the time of his death he had completed a very important study on the "United States of Europe" which was posthumously published: Vereinigte Staaten von Europa. Ein Weg zum europäischen Frieden (*Schweizer Monatshefte*, März 1932, 569-584).

We beg Mrs. HORBER to accept the homage of our deep respect and sympathy, and we reproduce below the obituary of her husband published in a Swiss periodical by Dr. ADOLF GRAF.

Schlicht, ohne Ehrentitel stand dieser Name unter den Todesanzeigen, und er wird bei vielen „Ehemaligen" die Erinnerung an einen Mann von ausgeprägtester Eigenart nachgerufen haben.

Prof. Dr. Carl Horber amtete nur wenige Jahre als Lehrer für Handelsfächer an der Kantonalen Handelsschule. Das war vor reichlich zwei Jahrzehnten. Bei vielen hat er als Lehrer den tiefsten Eindruck hinterlassen und viele werden es als ein gütiges Geschick betrachten, dass sie seine Schüler sein durften. Freilich war er wohl kaum das, was man so schlechthin einen guten, einen ausgezeichneten Lehrer zu nennen pflegt. Er packte alles etwas anders an als andere. Sein Spezialgebiet war der Rechtsunterricht. Wie er uns hier den Stoff entwickelte und dann völlig frei in ein Diktat zusammenfasste, war einfach meisterhaft. Vielleicht waren wir gar noch nicht reif für die hohen und feinen Gedanken, die er uns darbot. Ich wenigstens habe den Wert dieser Hefte aus den Stunden bei Prof. Horber erst später richtig würdigen können.

Carl Horber hat sich dauernde Verdienste um die Organisation der Tuberkulosenfürsorge und der „Pro Juventute" erworben. Er hat dabei Zeugnis abgelegt von nicht gewöhnlichen organisatorischen Fähigkeiten. Er war auch der Hauptinitiant bei der Gründung des „Bundes für Reformen der Uebergangszeit", einer Gründung, die an verschiedenen Klippen scheiterte, wiewohl die Idee grosszügig war.

In jahrelanger mühevoller Arbeit schrieb Horber sein Buch über „Die Schweizerische Politik". Ein ungeheures Material ist in diesem Werke verarbeitet. Eine gute Presse fand er nicht. Horber hatte die unbequeme Art, schonungslos die Grundübel unseres politischen Lebens zu brandmarken. Das Buch rüttelte auf und stimmte nachdenklich. Viele mögen bei der Lektüre unruhig geworden sein. Nichts verdriesst aber so sehr, wie wenn man in seiner Ruhe gestört wird. Mit einigen abfälligen Bemerkungen haben sich unsere politischen Blätter über die Verlegenheit hinweggeholfen oder sie haben das

Buch überhaupt totgeschwiegen. Und dennoch war es eine Tat. Geschrieben mit dem Herzblut eines guten Patrioten, aus den reinsten Absichten heraus. Dieser hervorragende Kopf erkannte klar die falschen Triebkräfte und die schlechten Organisationsmethoden des politischen und wirtschaftlichen Lebens. Horber, eine durch und durch vornehme Persönlichkeit, forderte eine Politik der dienenden Führung und entwickelte die Grundsätze einer befreienden Organisation. Diese befreiende Organisation sollte uns aus dem Sumpf des Bureaukratismus heraushelfen.

In Einzelheiten mag Horber zu schwarz aufgetragen oder ungerecht geurteilt haben, vielleicht kann man ihm auch vorwerfen, dass er nicht zu wenig, aber zu viel Distanz zum politischen Leben gehabt habe. Ein grosses Sündenregister hat jemand das Buch Horbers genannt. Mit gleichem Recht kann man es als eine Apotheose der grossen Persönlichkeit bezeichnen. Wo Horber von grossen Organisatoren und Führern spricht, da schweigt seine Kritik und findet er Worte der Bewunderung und der Dankbarkeit. Zufällig weiss ich, dass Horber, wenn er irgend eine Unternehmung beurteilen musste, weniger auf sachliche Momente abstellte als auf persönliche. Wer steht an der Spitze des Geschäftes? Ist das ein grosszügiger Geschäftsmann, hat er einen vornehmen Charakter? Amerika galt ihm als das Land, wo er sein Postulat des „Suchens nach dem Tüchtigsten" am besten verwirklicht glaubte. Indessen hat er Amerika entschieden zu optimistisch beurteilt. Er hat diesen Optimismus teuer bezahlen müssen.

Die letzte Lebenszeit Dr. Horbers war umdüstert von Sorgen. Ein grosses Unternehmen, das er geschaffen hatte und das er nach seinen Ideen leitete, fiel der Krise zum Opfer.

Carl Horber ist kein Diplomat gewesen. Sich anzupassen und Kompromisse zu schliessen lag seiner Art gänzlich fern. Er ging seinen eigenen Weg. Das, was er als richtig erkannt hatte, verfolgte er mit einer Hartnäckigkeit, die an Starrköpfigkeit und Eigensinn grenzen konnte. Deswegen schuf er sich oft Konflikte, unter denen er wohl selbst am meisten gelitten hat. Sein eigenes Verhalten hat nicht selten dazu beigetragen, dass selbst seine reinsten Absichten missdeutet und verkannt wurden. Das war sein Schicksal und die Tragik seines Lebens. Der Tod hat alles Zwiespältige gelöst. Uns bleibt nur noch das Bild eines vornehmen Menschen, dessen wir nicht anders als in Dankbarkeit gedenken können.

ADOLF GRAF.

(*Mitteilungen des Verbandes der ehemaligen Schüler der Kantonalen Handelsschule*, Oktober 1931.)

Mrs. Margaret Winifred Vowles (1883-1932). — Mrs. VOWLES, joint author with her husband, Mr. HUGH P. VOWLES, of "The Quest for Power," a comprehensive history of power engineering (see *Isis*, 18, 504), died at her home, Ridgway Place, Wimbledon, London S.W. 19, on March 4th, 1932. The funeral took place at Hucclecote, near Gloucester.

She was the daughter of Mr. FRANCIS T. PEARCE, of Lorraine House, Gloucester, was educated at the Cheltenham Ladies College, and took her B. Sc. (London University) before leaving in 1904. She was not only a distinguished historian, but was known throughout the West of England and South Wales as a county golfer of great proficiency.

In 1910 she married Mr. HUGH P. VOWLES, a friend of her childhood, whose interest in historical research she shared, and she often collaborated with him. We extend out deepest sympathy to her husband and their two sons.

G. S.

The 50th anniversary of Koch's discovery of the Tubercle Bacillus. — The Egyptian Medical Association (Anti-tuberculosis Committee) and the Bacteriological Society will join in celebrating KOCH's discovery of the Tubercle Bacillus.

A meeting will be held on Thursday, 24th March, 1932, at 7 p. m. in the Physiology Lecture Room, Faculty of Medicine, Cairo.

Dr. ALI TEWFIK SHOUSHA Bey, President of the Bacteriological Society, will speak about " The life of ROBERT KOCH " (in English).

Dr. ABDEL RAOUF HASSAN, Secretary of the Anti-tuberculosis Committee, will speak about " Evolution of Medical Ideas about Tuberculosis. Development of Anti-tuberculosis Campaigns after KOCH's discovery " (in English). He will also deliver an Arabic poem to celebrate the occasion.

Prix Binoux, 1932. — Le prix Binoux d'histoire et de philosophie des sciences a été attribué par l'Académie des sciences dans sa séance du 12 décembre à ABEL REY " pour l'ensemble de ses travaux sur l'histoire des sciences ". Les travaux d'ABEL REY, professeur à la Sorbonne, Directeur de l'Institut d'histoire des Sciences de l'Université de Paris et qui faisait partie du Comité de Patronage réuni par G. SARTON lors de la création d'*Isis*, ont été pour la plupart signalés dans cette Revue (1, 176; 2, 310; 4, 449, 451; 5, 484 f., 566; 8, 339 f.; 9, 477-79, 546; 11, 215; 12, 396; 15, 218, 437, 469; 16, 511).

L. G.

Reviews

Abu Naṣr al-Fārābī. — *Iḥṣa' al-'ulūm.* (Enumeration or classification of the sciences.) Edition of the Arabic text together with Arabic preface and notes by 'Uthmân Muḥammad Amîn. 24 + 80 p. Cairo, Al-Khānjī, 1350 (1931).

When I wrote the note on al-Fārābī in my *Introduction* (vol. I, 628-29), I still believed that the Arabic text of the *Iḥṣa' al-'ulūm* was lost, and yet by that time (1926) it had been not only discovered but published. This was a strange error on my part, because I alluded myself implicitly to the first Arabic edition on p. 629! However what shall we think of an Egyptian editor of the same text who writing ten years after the publication of the first edition still believes that his own is the first? (see p. 17 of his preface).

It is worthwhile to relate all the facts of this case as well as I know them, but before doing so let us dispose of the new so-called " first " edition. It has been done so carelessly that the editor has discredited himself by publishing it. The preface and notes are mediocre, and there is but little evidence of any attempt to produce a critical edition. Moreover the editor did not even bother to give any information about the manuscript used by him. He simply says that he used a photograph copy of a Ms. kept (the photograph) in the National Library of Egypt!

Thanks to the courtesy of Dr. Max Meyerhof and of Dr. Schaade I was able to elicit the following information from that Library. The photograph was made from a Ms. of the beginning of the seventh century H., which was found by Muḥammad efendi Amîn al-Khānjī (the well-known Cairene bookseller and publisher) in the course of a visit to Syria and was sold by him to an English society of orientalists (not the Royal Asiatic Society).

To return to the *first* edition, it was published in 1921 in the sixth volume of an Arabic periodical called *Al-'irfān* published in Ṣaïda (the ancient Sidon). I have a reprint of it covering 30 p. (numbered 3 to 32). This journal is small, of little importance, and hardly known outside of the Lebanon. Hence Western orientalists might be forgiven their ignorance of it, but for the fact that Father M. Bouyges (S. J.) devoted

to it one of his valuable notes " on the Arabic philosophers known to the Latin mediaeval scholars " as early as 1924 (No. VII, Sur le *de Scientiis* d'ALFARABI, récemment édité en arabe à Ṣaïda, et sur le *de Divisione philosophiae* de GUNDISSALINUS. Mélanges de l'Université Saint-Joseph, t. IX, fasc. 2, p. 49-70, Beyrouth, 1924).

The scholar to whom we owe that first edition of the *Iḥṣa al-'ulūm* is the shaikh MUḤAMMAD RIḌA AL-SHABĪBĪ who was then in Najaf (the holiest place of 'Irāq, where 'ALĪ is said to be buried), but is now living in Baghdād. From his preface to his own edition and from a letter which he kindly wrote me a short time ago (Baghdād, March 8, 1932), I gather the following facts. The shaikh AL-SHABĪBĪ found in Najaf, in or before 1921, a Ms. of the seventh century H. containing several philosophical books and epistles, including the *Iḥṣa al-'ulūm* and at least two other treatises by AL-FĀRĀBĪ, the one on the rules of prosody and the other on astrology. In answer to my query, he said that he had lost the Ms. but might perhaps be able to find it again. Let us hope that he will eventually succeed in finding it ! The shaikh's preface is far more elaborate than that of the new Egyptian edition.

I have roughly compared the editions of Ṣaïda and Cairo by reading the text of the one aloud to a friend whose eyes followed the other text. There are many variants, some of which are unimportant and may be due to the liberties taken by the oriental editors with their respective Mss. ; others however are more important and suggest that the two Mss. are independent.

Until recent times Western scholars knew this work only through the Latin versions of GERARD OF CREMONA and DOMINGO GUNDISALVO and through Hebrew versions, however the Arabic text far from being lost, is represented by at least four Mss., which I shall mention in their order of discovery :

(1) Escorial Ms. no 646 (H. DERENBOURG) or 643 (CASIRI).

(2) Ms. used by the shaikh AL-SHABĪBĪ and now lost.

(3) Ms. used by the Egyptian editor and now in England.

(4) Ms. discovered by Father BOUYGES in 1923 in the Kuprulu Library in Istanbul (no 1604).

These four Mss. together with the Latin and Hebrew translations should make it possible to prepare a scientific edition.

This note was already written when I heard from my honored colleague, Dr. ANGEL GONZÁLEZ PALENCIA, Professor at the University of Madrid (about whom see *Isis*, 15, 183-87, or *Introduction*, vol. 2, 6) that he was preparing such an edition on the basis of the Escorial Ms., the Cairene edition of 1931, and of the mediaeval Latin and *Spanish* translations. I hope he will be able to take advantage also of the other texts above-

mentioned. In any case we may depend upon him to produce a valuable edition which will advance our knowledge of the subject.

Beirut, Lebanon, April 15, 1932. GEORGE SARTON.

R. de Villamil. — *Newton :* The man. Foreword by Professor ALBERT EINSTEIN. VI + 111 p.; published by GORDON D. KNOX, 106 Guilford Street, London W.C. 1; 1931. Three shillings and six pence, net.

De persévérantes recherches poursuivies durant plusieurs années ont amené l'auteur à retrouver 860 des 1896 volumes que comprenait la bibliothèque de NEWTON, laquelle, après avoir disparu assez extraordinairement de la circulation pendant près de deux cents ans, fut mise en vente en 1920, sans qu'apparemment l'on se doutât de l'identité de son premier propriétaire; la plus grande partie des 1036 volumes restants est selon toute vraisemblance dispersée aux États-Unis. Ce lot de 860 volumes, dont certains avec des corrections et des annotations autographes, est aujourd'hui en vente chez Sotheran, à Londres. M. DE VILLAMIL a découvert en outre : 1) un catalogue complet (pp. 62-103) bien que dressé vers 1760, des ouvrages en possession de NEWTON au moment de sa mort; il existait d'ailleurs une liste semblable au British Museum; 2) un inventaire (1727) des biens terrestres du grand savant (pp. 49-61). Que de pauvres choses infiniment précieuses y sont décrites ! NEWTON voyait rouge (tout son mobilier est cramoisi, et, d'autre part, il est irritable : consultez CHARCOT...). Rien n'est mieux que d'éclairer la grande histoire par la petite : PEPYS ferme son journal pour cause d'astigmatisme, voilà qui nous rapproche de lui. Mais cette fois-ci, les coulisses sont hélas ! sans attrait. M. PICARD, dans une notice récente sur LIPPMANN, reconnaissait que « la vie des hommes de science ne présente pas en général une grande variété »; à fortiori quand ils sont anglo-saxons; leur existence est alors d'un affligeant conformisme. NEWTON, triste puritain sans fantaisie, se souciait peu de choses un tantinet subversives, sous quelque forme que ce fût. Au fond, c'était un empiriste; il a forgé, au fur et à mesure de ses besoins, des instruments nouveaux, mais en tant que mathématicien et physicien, il n'a pas modifié considérablement l'idéal de ses contemporains. Il est empiriste aussi dans son zèle à passer pour mécaniste, la physique du point de vue mécaniste étant une pure transcription de l'expérience, puisqu'elle ne fait pas intervenir de choses invisibles, des qualités occultes; en ceci, NEWTON obéit sans doute à la tradition de l'esprit anglais. N'est-il pas significatif que ce soit chez les hommes les plus intelligents que les caractères nationaux sont souvent les plus apparents ? Mme METZGER a écrit avec infiniment de sens qu' « il ne faut pas chercher dans le raisonnement avoué du savant mais plus

XUM

profondément, dans l'orientation même de sa pensée préalable à toute science, les raisons d'être de son attitude » (1). En lisant le livre de M. DE VILLAMIL, je me suis convaincu qu'une étude sur NEWTON et la pensée anglaise reste encore à écrire. L'auteur, en effet, effleure sans ordre un grand nombre de sujets : caractères de l'œuvre scientifique de NEWTON, vie privée etc.; il dit son mot sur des détails sans importance, mais laisse dépourvus de solution des points obscurs et n'établit rien, se basant sur ses propres impressions (2); ses considérations ne sont même pas toutes inspirées par les documents qu'il a le grand mérite d'avoir retrouvé. On nous promettait un NEWTON en pantoufles. Mais nous n'avons que les pantoufles.

J. PELSENEER.

J. F. Fulton. — *A Bibliography of the Honourable Robert Boyle, Fellow of the Royal Society*, by J. F. FULTON, M. A. Oxon., Formerly Fellow of Magdalen College, Oxford. Printed at the University Press by JOHN JOHNSON, 1932. Reprinted from the Oxford Bibliographical Society Proceedings and Papers, Vol. III, Part I, pp. 1-172.

This is at once a work of scholarship and a work of love, for Dr. FULTON (now of the School of Medicine, Yale University) has long been interested in ROBERT BOYLE and now possesses a unique collection of his works. The bibliography lists 42 separate works, by BOYLE or ascribed to BOYLE, details the characteristics of the various editions, and in each case gives a summary or an indication of the contents of the work. It is therefore interesting reading, for it shows the evolution of BOYLE's character and the spread of his interests, and relates him not merely to the history of science but to the history of English literature as well. We learn that BOYLE believed that rusting is caused by certain " saline " particles of the air which attach themselves to the surface of the metal and " dissolve " in it, and we learn that BOYLE's " Occasional Reflections upon Various Subjects " (1665) supplied the inspiration for SWIFT's " Occasional Meditations on a Broomstick " and " Gulliver's Travels." BOYLE's contributions to other works, including the Philosophical Transactions of the Royal Society, are also listed, complete collected works, collections, epitomes, Opera Varia, and theological collections, biographies of BOYLE, commentaries on his writings, dedications to him, and funeral sermons

(1) *Archeion*, XIV, 10, 1932.

(2) M. DE VILLAMIL attribue à NEWTON la paternité du calcul des variations, dont LAGRANGE était jusqu'à présent considéré comme l'inventeur. Ceci demande rait de nouvelles investigations.

and elegies. Finally, the Boyle Lecture Sermons and Robert Boyle Lectures are listed.

The book is beautifully printed; it has a frontispiece picture of the RYSBRACK bust of BOYLE and is illustrated with numerous facsimiles.

T. L. DAVIS.

J. R. Carré. — *La philosophie de Fontenelle ou le sourire de la raison.* 735 p., (*Bibliothèque de philosophie contemporaine*). Paris, FÉLIX ALCAN, 1932. (70 Fr.)

Ceux qui étudient la pensée scientifique en France, durant la première moitié du XVIII[e] siècle, rencontrent constamment et pour leur plus grande joie, les écrits de FONTENELLE sur leur route. Cet excellent secrétaire perpétuel de l'Académie royale des Sciences, s'il n'a pas été un découvreur de faits ou un créateur de théories, fut une intelligence ferme et lucide qui comprit fort bien l'œuvre de ses contemporains, et permit au public mondain et fort cultivé d'alors de pénétrer sans effort dans les travaux de grande valeur que les chercheurs exposaient souvent, à l'aide d'un langage maladroit, lourd et péniblement accessible. Les résumés des *Mémoires* qui forment la plus grande partie de l'*Histoire* rédigée par FONTENELLE ont excité l'admiration des savants eux-mêmes, qui dans les Mémoires suivants lui empruntaient ses expressions justes et frappantes.

Et pourtant, la renommée de FONTENELLE qui en son temps égalait celle des personnages les plus célèbres, a beaucoup décliné après sa mort; les professeurs de littérature n'ont été que très rarement charmés par la finesse, l'humour et la sagesse des *Dialogues des morts* ; ils ont trouvé les *Entretiens sur la pluralité des mondes*, trop peu graves, trop peu dignes de la vérité rébarbative de la science, et trop facilement intelligibles même pour les dames ; ils ont considéré les pastorales, les poésies, les lettres galantes comme des jeux de l'esprit, froids, secs, et sans intérêt; ils ont, il faut le reconnaître, fait une petite place parmi les précurseurs du siècle des lumières à l'auteur de l'*Histoire des oracles*, ouvrage à tendance irrévérencieuse, sinon pour la Religion établie, du moins pour la notion de miracle qui en est partie intégrante. FONTENELLE, sur lequel FAGUET et plus récemment M. RAYMOND LENOIR ont attiré l'attention, vaut mieux que sa réputation; il fut un grand écrivain, un vrai savant, un philosophe. M. J. R. CARRÉ lui a consacré une œuvre monumentale qui se lit avec plaisir et qui rend une justice tardive à cet esprit calme, pondéré, parfois silencieux ou volontairement ambigu, mais éminemment intelligent et réfléchissant constamment.

A vrai dire, ce n'est ni l'œuvre littéraire, ni l'œuvre scientifique de FONTENELLE qui ont, par leur forme ou leur contenu, attiré l'attention

de M. CARRÉ. Celui-ci s'est avant tout préoccupé de saisir le système philosophique caché dans l'âme de l'auteur dont les divers écrits ne dévoilent, par prudence ou indifférence, que des conséquences fragmentaires. Mais comme pour FONTENELLE, la grande affaire fut constamment de voir clair et de penser juste, la méthode de M. CARRÉ lui a permis de ressusciter de manière fort vivante l'esprit remarquablement immuable de son grand homme.

Nous ne pouvons ici insister sur les chapitres, d'ailleurs si intéressants, dévoilant quelle fut la forme de la sagesse de FONTENELLE, sa conception de l'homme, sa conception de Dieu, l'organisation de sa propagande ; il est pourtant bien important pour l'historien des sciences de connaître ce que FONTENELLE pensait des progrès humains ! Le secrétaire perpétuel de l'Académie des Sciences note les acquisitions du savoir et reconnaît que le développement de ce savoir est illimité. Pourtant, il ne croit pas à la perfectibilité de la race humaine. Les hommes ont accumulé des connaissances ; ils ont aussi inventé des procédés permettant de retenir fort facilement ces connaissances, certes; mais ils n'ont pu modifier le fonds de l'âme humaine ; les hommes naissent aujourd'hui semblables aux premiers hommes, et tous les perfectionnements dont notre civilisation est si fière s'accumulent par une sorte d'hérédité, ou mieux d'héritage social, qui n'ajoute rien au perfectionnement moral ou intellectuel de notre être ; FONTENELLE, dit M. CARRÉ, est un « croyant pessimiste au progrès » ; si sa conception de l'humanité n'autorise pas à certains égards des espoirs illimités, elle lui permet de réfuter l'opinion de ceux qui croient qu'au point de vue artistique ou littéraire, l'humanité a dégénéré ; dans la querelle des anciens et des modernes, FONTENELLE est aux côtés de son oncle THOMAS CORNEILLE, de CHARLES et de CLAUDE PERRAULT, pour les modernes, alors que leurs rivaux BOILEAU DESPRÉAUX, RACINE et LA BRUYÈRE sont pour les anciens. Il faut remercier M. CARRÉ de nous avoir parlé un peu des partisans des modernes que les purs littéraires dans leur goût exclusif de l'antiquité gréco-latine oublient généralement, sinon de mentionner, du moins d'étudier sérieusement. Il faut aussi remercier M. CARRÉ d'avoir consacré quelques chapitres à la Nature suivant FONTENELLE. C'est vraiment une étude d'ensemble sur FONTENELLE savant qui nous est présentée là, et dont nous recommandons la lecture. M. CARRÉ croit que l'on pourrait s'étonner que FONTENELLE resta toute sa vie cartésien en physique malgré le succès de NEWTON qu'il admirait et comprenait ; mais la lutte du cartésianisme et du newtonianisme dura tout le XVIII^e^ siècle ; et en 1770, treize ans après la mort de FONTENELLE, en 1786, vingt neuf ans après la mort de FONTENELLE, BERTIER et PARA DU PHANJAS condamnèrent l'attraction au nom du mécanisme cartésien ; si FONTENELLE fut obstiné, il le fut avec une

grande partie des physiciens craignant de laisser rentrer dans la science au nom de l'expérience, nombre de superstitions que l'action de FONTENELLE avait contribué à éliminer.

Nous pourrions continuer longtemps à réfléchir en compagnie de M. CARRÉ et de FONTENELLE sur la science au XVIII^e siècle ; il est temps de fermer le livre que beaucoup de lecteurs d'*Isis* ouvriront et liront avec plus d'intérêt que le plus passionant des romans.

Paris. HÉLÈNE METZGER.

The Life and Work of Professor William Henry Perkin, jr. — 138 p. The Chemical Society, Burlington House, London, W. 1., 1932.

The obituary notice, published as a special number of the *Journal of the Chemical Society*, contains an account of PERKIN's life (pp. 7-38, 3 portraits, picture of Oxford commemorative medallion) by JOHN GREENAWAY, and an account of his work, in two sections, the first by JOCELYN F. THORPE (pp. 38-74) on his early work, the formation of carbon rings, the chemistry of camphor, the chemistry of the terpenes, and miscellaneous research, and the second by ROBERT ROBINSON (pp. 75-128) on his work on the constitution of berberine, brazilin and haematoxylin, harmine and harmaline, cryptopine and protopine, etc. A list of his original memoirs (pp. 128-138) includes 271 titles. Four posthumous papers on strychnine and brucine are being prepared for publication.

WILLIAM HENRY PERKIN, Jr. (1860-1929) was the son of the chemist who prepared the first coal-tar dyestuff. He grew up in an atmosphere of scientific research and technical development. He entered the Royal College of Chemistry in 1877 where he studied under EDWARD FRANKLAND and W. R. E. HODGKINSON. In 1880 he went to Würzburg where he studied chemistry with WISLICENUS, physics with KOHLRAUSCH, and mineralogy with SANDBERGER, and received the Ph. D. degree in 1882. In the autumn of 1882 he went to Munich to work with BAEYER—and became Privatdozent at the University, remaining until 1886. In 1887 PERKIN became the first Professor of Chemistry at the newly founded Heriot-Watt College at Edinburgh. He left Edinburgh in 1892 and assumed the duties of Professor of Organic Chemistry at the Owens College, Manchester, succeeding SCHORLEMMER, where he remained for 21 years. From 1913 to the end of his life he was Professor of Chemistry at the University of Oxford, which he made one of the foremost centers of chemical research in England. His studies were devoted to the development of the possibilities of synthesis and to the elucidation of the constituton of various naturally occurring substances. PERKIN was one of the great organic chemists of the structural tradition.

XUM

The present obituary, like the Memorial Lectures and other publications of the London Chemical Society, is the sort of thing for which students of the history of science are grateful.

TENNEY L. DAVIS.

W. M. Feldman. — *Rabbinical Mathematics and Astronomy*, VIII + 232 p., London, M. L. CAILINGOLD, 1931. (10 Shillings, or $ 2.50.)

1. *The Book, its Object, Contents and Conclusions.*

The object of the book, as given in the author's preface and summary, is : " to explain the various mathematical and astronomical matters mentioned in the Talmud, and to investigate the extent of the mathematical and astronomical knowledge... revealed in this work and by its principal commentators." The book is divided into three parts, and these into eighteen chapters, as follows : Part I. Prolegomena : 1. What is the Talmud ? 2. Mathematics and Astronomy in Relation to Religious Legislation. 3. Some Mathematical Celebrities of the Talmud. Part II. Mathematics : 4. Mathematical Numeration and Notation of the Rabbis. 5. Mathematical Data and Theorems. 6. Talmudic Discussions in Which the Vatious Theorems are Utilised. Part III. Astronomy : 7. Astronomical Knowledge. 8. Astronomical Measurements. 9. Time of Sunrise and of Sunset ; Length of Day. 10. The Earth. 11. The Sun's Apparent Annual Motion. 12. The Moon. 13. Position of Moon in the Heavens. 14. KEPLER's Law and Gravitation. 15. The Visibility of the Moon. 16. The Examination of Witnesses. 17. The Fixed Calendar. 18. The Stars.

The conclusions arrived at are that " the ancient Jewish Rabbis were in respect of their mathematical knowledge more like the Babylonians, Egyptians and Romans, but certainly did not equal the Greeks... The whole of the mathematics found in the Talmud is entirely of a practical character." (1) Upon this there is a general agreement among scholars. However, in the astronomical part of his book, FELDMAN quotes at some length the theories of MAIMONIDES (d. 1204) and ISRAELI (14th century) without mentioning that these scholars drew freely from Arabic sources, which in their turn drew from Greek sources, and thus they show the influx of Greco-Arabic mathematics, which was quite the opposite of Rabbinical mathematics.

2. *Rabbinical Mathematics, a Borderline.*

Rabbinical mathematics forms a so-called borderline between two sciences, History of Mathematics and Hebrew Philology. A thorough knowledge of these two special fields and a good training in the general methods of modern philology and historical criticism are indispensable

(1) See the Summary, p. 220.

for a man who hopes to achieve a contribution of much value to this science. It is true, that FELDMAN shows, for a layman, a fair knowledge and understanding of both Rabbinics and Mathematics, but he displays a rather deplorable lack of historical and philological training. Modern scientific methods, the current literature of the subject, and a knowledge of the results achieved in the History of Mathematics as well as in Hebrew Philology,—all these seem quite unfamiliar to him.

3. *Alphabetical Numerals.*

In substantiation of this judgment a few examples may be cited. The first chapter of the mathematical part (p. 17) deals with the alphabetical numerals. All that FELDMAN seems to know about the subject is that " the Talmudic Rabbis " use the letters *aleph* to *taw* for the numbers 1-400. He quotes and, apparently, knows of no further literature about this rather interesting subject. He seems not to know that this usage was already well established in the Maccabean period (140 B.C.), or about 350 years before " the Talmudic Rabbis." Alphabetical numerals are to be found on the first Hasmonean coins. The probability, however, is that they were known already in Biblical times, or as early as 500-600 B.C., since the alphabetical order was already established as early as that, as is demonstrated by the acrostic or alphabetical arrangement of certain poems and psalms. He seems not to know that the Masoretes used the final letters *m n s p k* to designate the numbers 500-900. All this and various other details about the subject are well known and are discussed at some length in the following reference books : 1. TAYLOR, *The History of the Alphabet*, 1899, I, pp. 186-87. 2. *The Jewish Encyclopaedia*, under *Numbers and Numerals*, IX, pp. 348-50. 3. *The Encyclopaedia Britannica*, under *Numerals*, 11th ed., 1910, XIX, p. 867 ; 14th ed., 1929, XVI, p. 612. 4. GENESIUS-KAUTZSCH, *Hebrew Grammar*, 1910, pp. 29-30. 5. D. E. SMITH, *History of Mathematics*, 1925, II, pp. 53-59. 6. M. CANTOR, *Geschichte der Mathematik*, I, 3rd ed., 1906, pp. 120-130, and especially pp. 122, 126-27 (2). In all these general and standard works, some of which were written a quarter of a century before FELDMAN's book, more and better information on the subject is found than he has given. It is quite apparent that FELDMAN has written a special book on Rabbinical mathematics without knowing what these general reference books have to say about the subject.

(2) Cf. also the special literature on the subject, like : HALLO, *Zeitschrift der Deutschen Morgenlaendischen Gesellschaft*, vol. 80, 1926, pp. 55-67; E. LOEFFLER, *Ziffern und Ziffernsysteme*, 1912; F. DORNSEIFF, *Das Alphabet in Mystik und Magie*, 2nd ed., 1925, pp. 11, 91 ff., and the further bibliography quoted in these books and in the reference works mentioned above.

4. *The Hindu System of Decimal Notation.*

The passage on the alphabetical numerals is followed by the statement that " the Rabbis were also aware of the decimal system of notation, which, they state, they adopted from the Persians." If true, historians of mathematics would certainly hail the discovery as a great sensational find. The fact, however, is that there is not the slightest foundation for the statement. Neither the Persians nor the Rabbis were aware of the decimal system of notation. Hence the Rabbis did not adopt it from the Persians nor did they make a statement to that effect. The passage in the Talmud (3), quoted as proof, only says that " in Persian arithmetic they call the ten one," i.e. they have one *number word* for one and ten (4). But no mention is made of one *number sign*, or numeral, for one and ten. The whole context in the Talmud speaks only of spoken number words and not of written number signs.

It may also be noted that this discovery was simply taken by FELDMAN from the article *Mathematics* in the *Jewish Encyclopaedia* (5) without naming the source. BROYDÉ, the author of the article, says : " Even the decimal system (sic !) is alluded to by Rabba." Thus BROYDÉ did not know the difference between the decimal system of *numeration* and the decimal system of *notation*. FELDMAN tacitly corrects the error but omits to name BROYDÉ as his source.

5. *The Mishnat ha Middot.*

On p. 23 FELDMAN says that " as early as the second century C.E. the 49th (sic !) Middoth of Rabbi NATHAN gives the value of π as $\frac{22}{7}$." That information FELDMAN expressly gives us on the authority of BROYDÉ's article *Mathematics* in the *Jewish Encyclopaedia*. The same blunder, " 49th " instead of " forty nine," was made in the *Jewish Encyclopaedia* and FELDMAN perpetuated it. But why did not FELDMAN take the trouble of looking up that old Talmudic treatise, " the forty nine Middot of Rabbi NATAN," going back to the second century and having a more exact formula for π? Why did not FELDMAN take the trouble of looking

(3) *Bekhorot* 60a; *Ho'il we'iteh beminyānā parsa'ah diqerō la 'asarah ḥad.*

(4) I am unfamiliar with the Persian language, and, therefore, unable to verify this Talmudical statement. From the Persian dictionaries and grammars I glean that *dah* means ten and *yak* means one. *Dah yak* means " one tenth," since the word *yak* placed after another numeral forms a fraction. It is possible that the Talmud alludes to that peculiarity. In the Persian-English Dictionary of STEINGASS, p. 547, I find : " *Dah=ten*, indicating sometimes a large, sometimes a small number." I do not know what this means. Does it also indicate the small number " one "? In that case it would confirm the Talmud.

(5) VIII, p. 375. The article was known to FELDMAN, for he refers to it in other passages.

up the *Mishnat ha Middot*, quoted by BROYDÉ in the same article and on the same page as the oldest mathematical work written in Hebrew? There is one answer to both questions. Both, FELDMAN, the author of *Rabbinical Mathematics*, and BROYDÉ, the author of the article *Mathematics* in the *Jewish Encyclopaedia*, were unaware of the fact that the "49 Middot of Rabbi NATAN" and the "Mishnat ha Middot" are one and the same book. BROYDÉ never saw the book; he quotes it from hearsay, that is from secondary sources which cited it under two different names and which had contradictory theories about its date. Hence he quotes it as two different books. Once it is the "49 Middot of Rabbi NATAN" going back to the second century C.E., and immediately hereafter it is the "Mishnat ha Middot" belonging to the Judaeo-Arabic period. Dr. FELDMAN became confused, was unable to find the book in the hurry, so he simply copied BROYDÉ. Thus FELDMAN wrote his book on "Rabbinical Mathematics" based on small, incoherent, occasional fragments from the Talmud; but the Mishnat ha Middot, the special Talmudic treatise on mathematics, remained unknown to him. He frequently quotes SAVASORDA (c. 1100), and ISRAELI (14th century); in various public and private libraries he searches for manuscripts of MAIMONIDES's code dealing with the calendar (6), although each of these three authors represents the later introduction of Greco-Arabic mathematics. But the oldest, the only, the classic and most important Rabbinic book on mathematics remains unknown, is passed over in silence. This in spite of the fact that it was published twice, by STEINSCHNEIDER and SCHAPIRA, that BROYDÉ, his source, quoted it under two names and referred to its editions in his bibliography (7).

As to BROYDÉ's article in the *Jewish Encyclopaedia*, it does not do the man justice. He was a man of decided ability, but it is evident that the article was prepared in haste without the opportunity of consulting the necessary sources. And yet, his article, published in 1904, in spite of all its shortcomings and mistakes, shows more scientific method and gives a better historical view than FELDMAN's book.

6. *A Starting Point for Critique.*

Dr. FELDMAN is the Senior Physician at St. Mary's Hospital, Plaistow. As such he apparently had his own doubts about his qualification for

(6) See the Preface, p. VIII.

(7) Recently the writer of this review referred to the importance of the Mishnat ha Middot in about half a dozen papers. In the *Hebrew Union College Annual*, VI, 1929, pp. 263-276, the writer published the Prolegomena to a new edition. This new edition has just appeared in the *Quellen und Studien zur Geschichte der Mathematik*, A2, Berlin, 1932.

XUM

this new venture in Rabbinical mathematics. Hence two authorities, Professor R. A. SAMPSON, Astronomer Royal for Scotland, and Professor ADOLF FRAENKEL, were invited to write Prefaces and introduce him to the Rabbinico-mathematical public. Of these the latter, Professor FRAENKEL, realising the weaknesses of the book, writes in his Foreword as follows : " It is of no great importance that this book gives certain opportunities for criticism, or that one may have dissenting opinions concerning certain theses, in consideration of the fact that the appearance of this work presents a welcome starting-point for critique and further investigation." I fully agree with Professor FRAENKEL. FELDMAN's book is by no means a solid foundation, or a reliable source of information, but " a welcome starting-point for critique and further investigation."

SOLOMON GANDZ.

Léon Brunschvicg. — *De la connaissance de soi*, 196 p., Paris, ALCAN, 1931.

Du moment que « l'homme tend à se constituer une destinée spirituelle au rebours de la fatalité qui est le caractère du rythme biologique » (p. 196), il s'agit, pour le connaître vraiment, de suivre la réalisation progressive de ses aspirations; et voilà pourquoi cette étude *De la connaissance de soi*, qui est, à proprement parler, une « Anthropologie », au sens étymologique du terme, est présentée dans un cadre historique autant que philosophique.

M. BRUNSCHVICG en a trouvé les divisions dans les perspectives diverses ouvertes par lui sur les différents domaines de l'activité humaine : il nous place ainsi « en face d'un progrès d'orientation qui transformera, dans un même sens et d'ensemble, toutes les fonctions de l'humanité » (p. 24). Au cours de ces substantiels chapitres, dans lesquels la *nature* de l'homme nous apparaît constamment plus dynamique que statique, on a plaisir à suivre, avec l'auteur, cette évolution, tantôt marche triomphale, tantôt laborieuse gestation, toujours création de valeurs nouvelles, ascension constante vers les sommets inaccessibles, que l'humanité hausse elle-même, en quelque sorte, à mesure qu'elle s'y élève, comme pour être sûre de n'avoir jamais achevé sa marche et de n'avoir pas à s'arrêter dans un repos trop voisin de la mort. M. BRUNSCHVICG a bien raison, pour nous montrer « jusqu'où l'homme peut monter » de nous faire d'abord « descendre jusque là d'où il prendra son élan ». Bien loin d'être déprimant, ce retour sur nos origines est un réconfort, parce qu'il nous montre qu'à travers les élans, les chutes, les sursauts et les efforts, se poursuit l'interminable course au progrès. « Force d'élasticité », « vertu d'expansion », ces expressions qui reviennent volontiers sous la plume de M. BRUNSCHVICG pour caractériser l'élan humain, sont tout à fait

à leur place dans un tel ouvrage, dont les développements en enrichissent sans cesse chez le lecteur la signification.

A un autre point de vue encore, la méthode suivie par l'auteur est fort intéressante : elle témoigne en effet d'une répugnance à l'égard des formules d'antithèse et des fausses fenêtres, introduites surtout pour des raisons de symétrie... à moins qu'il n'y ait «parti pris d'illusion systématique ». En présence des oppositions traditionnelles, « nous devons, dit-il, avoir soin de nous demander si les termes de l'alternative n'ont pas été artificiellement raidis, cristallisés dans leur définition, afin de donner un jeu plus aisé à la dialectique du *morcelage*, à l'éloquence des antithèses ». (p. 59). La façon plus compréhensive (j'évite à dessein le terme *synthétique*, qui pourrait évoquer les idées de thèse et d'antithèse) de voir le développement humain, préconisée et très judicieusement mise en pratique par M. BRUNSCHVICG l'amène à rattacher non seulement, *l'homo sapiens*, à *l'homo faber*, mais celui-ci même à *l'homo religiosus* par leur commune rencontre originelle dans *l'homo magicus* (cet homme de la magie qui se survit d'ailleurs, en quelque sorte, à lui-même jusqu'à notre époque).

En ce qui concerne le passage de la magie à la science (c'est, parmi les problèmes étudiés dans ce livre, un des plus importants), il s'accomplit, d'après M. BRUNSCHVICG « au delà de la technique » (p. 69); parce que, pour lui, « un savant, au sens propre du mot, ce n'est pas seulement celui qui sait que ce qui est vrai est vrai, c'est celui qui se rend compte que ce qui n'est pas vrai n'est pas vrai » (p. 67), ce qui revient à dire, sous une autre forme, que le passage du plan de la technique à celui de la science suppose « une véritable conversion de l'esprit humain ». Peut-être conviendrait-il d'ajouter que cette conversion est lentement, mais continuellement, préparée par l'évolution même de la technique, un peu à la façon dont le papillon sort de la chrysalide sous une forme toute nouvelle certes, et pourtant pas absolument indépendante. En d'autres termes, s'il est bien exact de dire que le savant est « celui qui se rend compte que ce qui n'est pas vrai n'est pas vrai », il n'en reste pas moins qu'il y a, en quelque sorte, des degrés dans la façon de s'en rendre compte, depuis le simple soupçon jusqu'à la certitude. Ce point n'est pas subsidiaire, comme certains pourraient le penser, mais fondamental au contraire par les conséquences méthodologiques qui en résultent pour l'historien des sciences.

M. BRUNSCHVICG a raison de mettre celui-ci en garde contre un des dangers qu'il y a à suivre *à rebours* l'histoire de la science. On risque en effet d'admettre trop volontiers que tout ce qui a pu prendre au cours des siècles une valeur scientifique avait cette valeur originairement, quelles qu'aient été ses conditions d'apparition et ses concomitances,

XUM

et d'attribuer par conséquent à des alchimistes, par exemple, des découvertes qui n'existent que pour nous et qui n'existaient pas pour eux, parce qu'elles ne se trouvaient en somme dans leurs écrits que mêlées à tout un fatras de recettes qui en masquait la véritable signification. Certes la prudence, en ce domaine, est particulièrement nécessaire à l'historien des sciences; mais il doit se garder aussi à l'inverse, en vertu de ce que nous venons d'ajouter (au moins explicitement) à l'idée de M. BRUNSCHVICG, de refuser toute valeur scientifique à une anticipation géniale, sous prétexte qu'elle perd dans l'ambiance où elle est jetée le caractère de netteté et de précision qu'elle ne peut revêtir que dans son rapport à nos théories modernes. En résumé, nos connaissances actuelles (à travers lesquelles nous voyons, malgré nous, plus ou moins les doctrines scientifiques anciennes) ne doivent nous inciter ni à ajouter ni à retrancher aux connaissances des savants antérieurs; si nous ne pouvons faire de l'histoire des sciences qu'*à rebours*, nous devons, autant que possible, nous insérer, par un effort de pénétration sympathique, dans le courant même de la pensée scientifique de telle ou telle époque. En nous invitant, par ses remarques, à nous en souvenir, M. BRUNSCHVICG nous ouvre des horizons qui dépassent le problème philosophique déjà si vaste qu'il a si heureusement posé.

PIERRE BRUNET.

John Butler Burke. — *The Emergence of Life.* Being a Treatise on Mathematical Philosophy and Symbolic Logic by Which a New Theory of Space and Time is Evolved. VIII + 396 p. Oxford University Press, 1931. (Price $ 7.50.)

In the volume before us we find a curious mixture of the metaphysics of monadology and the mathematical methods of symbolic logic. The author, beginning with the premises of HEGELian dialectic, the absolute ideal, the antinomies of KANT, and the monads of LEIBNITZ, ends with the PLATONic theory of ideas. In this blending of the concepts of many important philosophical systems we are led by not too obvious connections through a maze of ideas and emerge in the final chapter with the following conclusion which is, perhaps, the best epitome of the book : " As LEIBNITZ supposed all atoms to have a trace of consciousness, we suppose all ideas, not only to have an independent reality, but to be endowed with some degree of consciousness... Thus a consistent idealism would lead one to infer that not only those ideas which we call monads and atoms are self-conscious but all ideas, and that these are self-existent. This generalization brings the PLATONic theory in harmony with LEIBNITZ's notion."

In the present volume the author enlarges upon ideas which he has

developed in several articles and a previous book: "The Origin of Life" (1906), to establish a continuity of life through inanimate material, to prove the existence of " radiobes " in radium, the principle of " biogen " in living matter etc. " My subsequent studies," he says, " have convinced me that innumerable Egos, as LEIBNITZ supposed in his ' Monadology,' must form the basis and the true structure of reality." Unfortunately there is lacking unassailable experimental evidence of the existence of these metaphysical agents and however persuasively the author may argue for their reality and develop the implications which follow from their existence, one cannot help but feel that the book is an extrapolation which goes far beyond the range of scientific experience. It is interesting, however, to see how the author continually blends modern ideas with his monad concept as, for example, when he concludes that the transfinite number (two raised to the aleph-zero power) which CANTOR used to measure the points of the mathematical continuum, also measures the totality of monads.

The author in the beginning of his book takes the laudable scientific attitude that " people must know exactly what they mean by the terms they employ and the propositions they assert " and then proceeds to assert that " the dissipation of energy is a transformation in another ' direction ' from greater to smaller." The words *monad* and *idea*, which as we have already said occur as the central concepts of the book, do not seem to admit of clear definition. The reviewer does not wish to appear to found his epistemology upon the words of Lord KELVIN : " I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it ; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind." Nevertheless, if one cannot define a word in terms of more or less precise meaning or, in lieu of this, frame a set of consistent postulates about his word, then the knowledge is of a meager and unsatisfactory kind. As an example we might cite the concept of aleph-zero which we have mentioned in the preceding paragraph. This number, the *nec plus ultra* of abstractness, may be defined as the solution of the equations : x plus any finite number equals x ; x plus x equals x ; x to any finite power equals x. A definite conceptual significance is thus given to the abstract idea of infinity and one can proceed to manipulations with it.

Perhaps one goes too far in insisting that similar criteria be applied to any concept which is to be brought within the realm of scientific speculation. However, since the author has himself insisted upon this point of view, it seems necessary that he should follow it. It is to be admitted that he has made an attempt to define " idea " as " the unit

of the substance of thought," the " unit of perception " etc., but he exhibits the inherent difficulties of the situation in the statement that " the perennial embarrassment of philosophers can be traced to the meaning they attach to these words." Nowhere is scientifically precise meaning attached either to monad or idea. Neither spacial nor temporal precision seems possible, although an attempt is made to associate them with new concepts about both space and time.

The reviewer has sympathy with the idea expressed by the author that there exist fundamental antinomies in nature. The following quotation is significant and timely : " Scientific researches, if consistently pursued, lead inevitably, whatever apologists might say, to results that, so far as the Aristotelian logic is concerned, must be regarded as ultimately inconsistent dogma... The scientist finds himself in fact very much where KANT did, except that his dilemmas are not confined to the four antinomies, as KANT imagined himself to have been limited ; but in truth to contradictions that occur, wherever he might turn his eye, and whatever he might contemplate." This thesis is well worked out and is brought into consonance with the HEGELian dialectic.

It is interesting to see the attempt made by the author to unite the precise language of mathematics with the undefinableness of his *monads* and *ideas*. The reader will find here a clear exposition of the symbolic logic of GEORGE BOOLE combined with some of the more modern symbolism of G. PEANO. The chapters on " Algebraic Analysis," " General Principles," and " Existential Propositions " (about 50 pages) form a very good introduction to the technical language and methods of symbolic logic. It is illuminating to see how the author has translated the philosophies of KANT, SCHELLING, and HEGEL into this symbolic language. One may remark, however, that since mathematical manipulation cannot yield more than exists in the original definitions and postulates, this formal casting of abstract philosophical systems into mathematical language cannot yield more concrete conclusions than were first put into the system by definition.

One of the most interesting chapters of the book is based upon the laws of chance, or more specifically, upon the rules of BAYES on inverse probability, particularly as it applies to the theory of testimony. The author invokes this very much assailed rule as fundamental to a discussion of HUME's celebrated statement that no amount of human evidence could prove a miracle. By specious assumptions the author concludes that HUME was not necessarily correct.

Other topics discussed by the author are : emergent evolution, the nature of substance, (in which he is strongly Berkelian), the nature of time and space, heredity, variation, and relativity. In a chapter

largely mathematical the author proposes his monadology of relativity in which he asserts that " space is the order of coexistence of monads forming an event " and a wave " constitutes a rearrangement of all monads in space."

The treatment of heredity and variation is almost impossible to understand because of the curious analogies introduced between mathematical formulas, properties of numbers, and experimental facts. Mathematics is not used here in its usual application as a method for formulating postulates in precise form, but rather as an analogy which often tends to obscure rather than illuminate. Thus, series of numbers created by adding multiples of six to 1, 3, and 5 are introduced *ad hoc* into a discussion of MENDEL's laws of heredity. FOURIER series are brought into a discussion of biological variation and the fact that the number 10^{13} occurs as a ratio between present estimates of the dimensions of the galaxy, the solar system, an earthly object, the electron, and the photon is introduced without other justification than analogy into the phenomena of growth, reproduction, and heredity. One must, however, never be wholly unmindful of the somewhat similar use of numbers made by JOHANN BODE in stating his " law " for the distribution of planets and the service which it rendered to astronomy.

The reviewer wishes to quote with approval the statement made by the author regarding the science of economics in which he says that " discussions will ultimately turn not only upon statistics and their degree of accuracy, but upon the mathematical analysis of the facts by the theories of probability." This is the first tenet of the newly established Econometric Society. The author remarks that Professor F. Y. EDGEWORTH was " among the first, if not the first " to show that economics may be studied by mathematics. In the classical thesis by JACQUES MORET : " L'Emploi des mathématiques en économie politique " (1915) the history of this growing movement was traced and it was there shown that the first epoch was from 1711 to 1800 and the second epoch from 1800 to 1870. The modern period began with the work of WILHELM LAUNHARDT and F. Y. EDGEWORTH and their pioneer labors are beginning now to bear fruit.

Indiana University. H. T. DAVIS.

Charles Sanders Peirce. — *The Collected Papers of Charles Sanders Peirce*. Edited by CHARLES HARTSHORNE and PAUL WEISS, vol. 1. Principles of Philosophy. The Harvard University Press, 1931. (Price, $ 5.00).

The full parade of the collected views of any thinker always furnishes an impressive spectacle. Here we find the sum total of a life of reflection,

the total strivings of a single mind in its endeavor to probe universal problems. For the first time the complete system is envisaged and we are able to appraise the success which has been attained.

In the volume before us we have the first contribution of a collection of ten projected volumes in which the work of CHARLES SANDERS PEIRCE (1839-1914) will be set forth. The first volume is devoted to the Principles of Philosophy, " the second will deal with the theory of signs and meaning, traditional logic, induction, the science of discovery and probability ; and the third volume reprints his published work on modern logic. The fourth includes his unpublished original contributions to the foundations of mathematics, logic, and graphs. The fifth volume contains his papers on pragmatism. The sixth is concerned with metaphysics." The editors plan to complete the work with some volumes which will contain the author's writings on physics and psychology, his reviews and letters, and a biography.

The total work is collected from seventy-five published articles, about twice as many book reviews, and several hundred unpublished manuscripts which represent all stages of incompleteness. It will be seen from this that the work of the editors has been more exacting and difficult than is usually the case in a project of this kind and they have performed their task with exceptional skill and judgment.

The present volume is divided into four books entitled :(1) General Historical Orientation ; (2) The Classification of the Sciences ; (3) Phenomenology ; and (4) The Normative Sciences.

Perhaps the greatest justification for the existence of philosophers is the cosmic range of their ideas, the interpretations which they make on the basis of broad views of knowledge. This applies particularly to Professor PEIRCE who was a man of extensive learning. In the beginning the author sets himself the task of classifying all scientific knowledge. He had originally projected a history of science, but in this task did not go beyond general philosophical contemplation. His classification, which was necessarily somewhat arbitrary, possesses much interest, particularly in the arguments which he employs to justify the relative positions of the various sciences.

The genuine insight into the nature of scientific research, which Professor PEIRCE possessed, is clearly revealed in his characterization of a man of science. He first classifies men into three types : (1) the man of feelings who becomes the poet and the artist ; (2) the man of temporal power, who carries on the business of the world ; (3) the man " to whom nothing seems great but reason," who becomes the scientist. " If a man burns to learn," he says, " and sets himself to comparing his ideas with experimental results in order that he may correct those

ideas, every scientific man will recognize him as a brother... But if a man occupies himself with investigating the truth of some questions for some ulterior purpose, such as to make money, or to amend his life, or to benefit his fellows, he may be ever so much better than a scientific man, if you will,... but he is not a scientific man... The genuine scientific chemist cares just as much to learn about erbium—the extreme rarity of which renders it commercially unimportant—as he does about iron." One cannot forbear supplementing this statement with the words of HENRI POINCARÉ : (The Foundations of Science, Science Press (1913), p. 366) " The scientist does not study nature because it is useful ; he studies it because he delights in it and he delights in it because it is beautiful. If nature were not beautiful, it would not be worth knowing, and if nature were not worth knowing, life would not be worth living... Intellectual beauty is sufficient into itself, and it is for its sake, more perhaps than for the future good of humanity, that the scientist devotes himself to long and difficult labors."

In connection with this appraisement of the man of science, Professor PEIRCE shows his appreciation of the study of the useless. " Now contemporaries of KEPLER," says the author, " were abandoning the study of geometry... because they said it was so *utterly useless*. There was the future of the human race almost trembling in the balance, for had not the geometry of conic sections already been worked out in large measure and had their opinion prevailed that only sciences apparently useful ought to be pursued, the nineteenth century would have had none of those characteristics which distinguish it from the *ancien régime*. True science is distinctively the study of useless things. For the useful things will get studied without the aid of scientific men. To employ these rare minds on such work is like running a steam engine by burning diamonds." We cannot have too many words like these. Here is full justification for those strange men who have striven so long to discover whether or not four tints is sufficient to color any map. But as the work of those who struggled to prove the parallel postulate of EUCLID has found full justification in the ideas of EINSTEIN and the new physics, so it may be hoped that the four-color problem will finds its justification in the problem of the stability of our system of planets. So smoke rings led to the vortex theory of the atom and the tossing of dice to life insurance and the kinetic theory of gases.

In stating his philosophic faith, Professor PEIRCE places himself squarely in the ranks of the realists. In doing so he indicates opposition to the imposing array of nominalists who rank among their members DESCARTES, LOCKE, BERKELEY, HUME, WILLIAM OCKHAM, KANT and HEGEL. The author especially deplores the disdain so often expressed by the latter

XUM

for scientific men and the modes of scientific thought. "It was a misfortune for Hegelism, a misfortune for philosophy and a misfortune in lesser degree for science."

In the third part of the book the author devotes his attention to the *phaneron*, by which he means the "collective total of all that is in any way or in any sense present to the mind quite regardless of whether it corresponds to any real thing or not." The development of this theme, put together by the editors from a number of sources, is made by means of a set of categories. This part of the book appears somewhat disconnected and is phrased largely in abstract philosophical concepts. It must be said, however, that the clarity of the author is in sharp contrast to that of many other writers because he is always careful to define his terms. Abstract though his thought may be it is always founded upon definitions which are as exact as language and illustration can make them.

The volume throughout is stimulating to the imagination and although the ideas are not always worked out with completeness they are rich and varied. In one place, with ideas fixed upon the then important vortex theory of the atom, the author develops the theme that man is a wave but not a vortex. In another, discussing theories of evolution, he is led to envisage the universe of time in terms of spirals, three equations for which he suggests. In another he reviews the doctrine of probabilities in its application to the determination of the *ket*, an Egyptian unit of weight, the data used being chosen from the memoir on Egyptian Exploration (1886) by Professor W. M. PETRIE. He pursues by many arguments through a number of fields of thought the theme that there is a fundamental trichotomy in philosophy although he resists, in a short essay, "the anticipated suspicion that he attaches a superstitious or fanciful importance to the number three, and forces divisions to a Procrustean bed of trichotomy."

The reviewer hopes that he has made it clear that the present volume is a fine addition to the literature of science and philosophy and that other volumes of the set are to be awaited with genuine anticipation.

Indiana University. H. T. DAVIS.

Collected Papers of Charles Sanders Peirce. — Volume II: *Elements of Logic*. Edited by CHARLES HARTSHORNE and PAUL WEISS. Harvard University Press, Cambridge, Mass. $ 6.00.

This volume, the second of the projected ten-volume edition of PEIRCE's papers and correspondence, is made up of a variety of non-symbolic contributions to logic, the symbolic developments having been reserved for later volumes. Of the material in the present volume nearly half is new to the literature; the remainder consists of reprints. The volume

may be viewed as falling into two major divisions, corresponding respectively to Books I and II and to Book III : the first division treats of what we should ordinarily call the philosophy of logic, while the second is occupied with deductive and ampliative inference.

In Book I, which is part of the unpublished and unfinished *Minute Logic*, PEIRCE reviews and rejects a variety of historical and contemporary doctrines as to the nature of logic. The general point of view which he most vehemently opposes is the attempt of the German logicians of the nineteenth century to construe logic psychologically, basing the validity of logical principles upon an ultimate subjective *Rechtsgefühl*. The Euclidean basis of self-evidence represents the same general point of view, as does the criterion of clearness and distinctness emphasized by DESCARTES and LEIBNIZ, and also the criterion of the inconceivability of the denial, as adopted by SPENCER and others. PEIRCE contends that the study of logic would be superfluous unless this pristine sense of logicality were fallible, and that the whole point of discriminating right from wrong reasoning presupposes the notion of objective truth independent of belief. The proper test of the validity of a given argument is an inquiry into the general nature of things for a basis of that validity. The supposedly infallible common-sense judgments or instincts regarding the validity of arguments, he maintains, are themselves founded on the same sort of objective inquiry, " and differ from the judgments of scientific logic only in resting upon vaguer and less distinct thought. "

Prior to all logic, PEIRCE holds, we are aware of " mathematical " necessities; an example is our inability to believe each of two contradictory propositions. Logic is subsequent to and dependent upon mathematics. Regarding the nature of this mathematical reasoning, PEIRCE comes close to KANT (1); the archetype of such reasoning seems to involve experimentation with diagrams, actual or imaginal. PEIRCE does not seek to found the validity of mathematical reasoning upon any metaphysical basis of pure intuition, however, but contemns rather all false philosophical pretense of doubt and declares that mathematical reasoning, self-evident as it is, demands neither faith nor substantiation. In the matter of a criterion of logical validity, therefore, it is difficult to detect any fundamental difference between PEIRCE's view and the German or Cartesian doctrines which he opposes : self-evidence, instinctive common sense or *Rechtsgefühl* is retained in full force as the final touchstone of logical truth, at the level of the so-called mathematical reasoning. The basis of distinction between PEIRCE's objective view and the German subjectivism seems to consist in the fact that truth, for PEIRCE, does not

(1) *Critik der reinen Vernunft*, 1st ed., p. 163.

consist in a momentary acceptance by reason, or a present inconceivability of falsity, but rather in " a final, unshakable compulsion " preventing one ever to imagine the falsity of the proposition. The proposition whose falsity is inconceivable is " true by definition, if by inconceivable is meant eternally inconceivable." Such a notion of truth is consistent with PEIRCE's futuristic point of view; " conclusions of reasoning are always of the nature of expectations." " But a definition is not a criterion;" for a criterion of the validity of a reasoning process PEIRCE is ultimately driven, with his self-justificatory "mathematical" reasoning, to a basis not unlike the *Rechtsgefühl* which he condemns.

Book II, a patchwork of short reprints and hitherto unpublished fragments, is given over to a discipline whereof PEIRCE is the founder : the theory, namely, of signs. " The sign stands for something, its *object*." Further, the sign " addresses somebody, that is, creates in (his) mind an equivalent... or... more developed sign, (called) the *interpretant* of the first sign." PEIRCE classifies signs as follows. An *icon* refers to its object merely by virtue of characters of its own which are independent of the existence of that object. The icon is independent of dynamical connection with its object; the sign-using mind contrives merely to discern a resemblance of qualities, as between a peculiarly eroded cliff and the profile of Washington. Only by icons can we directly communicate an idea. An *index* refers to its object through being affected thereby : consider the pointer-reading of a recording instrument. Every matter of fact requires an index in its expression—a proper name or a spatial or temporal adverb, spoken, gesticulated or tacitly understood. A *symbol*, finally, has its reference by virtue of an association of general ideas; its connection with its object depends wholly upon a convention of the symbol-using mind, such as that which relates the typographical form " cat " with the well-known type of quadruped, or the notion " theater ticket " with entrance privileges. A symbol is a universal; any concrete instance of a symbol, e.g. an individual utterance of " cat " or a concrete theater ticket, is called a *replica* of the symbol.

PEIRCE further trichotomizes signs as *qualisigns*, *sinsigns* and *legisigns*, according as they are qualities, existent things (or events), or laws. The third and most important trichotomy is as follows : according as a sign is represented by its interpretant as being an icon, an index or a symbol of its object, it is called a *rheme*, a *dicent sign* or a *suadisign*. He shows that a qualisign must be a rheme and an icon, and that a suadisign must be a symbol and a legisign. Iconic sinsigns and iconic legisigns must be rhemes; rhematic symbols and dicent symbols must be legisigns; dicent sinsigns must be indices. Of the twenty-seven classes resulting from superposition of the three trichotomies, seventeen are therefore

eliminated; ten classes stand. The rhematic symbol, the dicent symbol and the suadisign are the most important of these ten kinds from the standpoint of ordinary logic. The first turns out to be the *propositional function* of WHITEHEAD and RUSSELL's *Principia Mathematica*, written $\phi\hat{x}$, $\psi(\hat{x},\hat{y})$, etc. in that work. The second is the ordinary *proposition*. Suadisigns, finally, prove to be logical *arguments*.

From the definitions of his terms, PEIRCE deduces certain general characters of dicent signs. The interpretant of the dicent sign represents the latter as of two parts, a *subject*, which is an index (or a sign of an index) of an existent object, and a *predicate*, which is an icon (or a sign of an icon) of a quality or essence; the interpretant construes the dicent sign as a whole as an index of a fact of connection between that existent object and that essence. If a dicent sign is true, it will be an index as its interpretant represents it to be; hence its object will be an actual existent, as must the object of any index. (Where the true dicent sign is a symbol, PEIRCE can only mean that this indicial character attaches to its replicas, since a symbol cannot be an index.)

As to propositions whose subjects are not proper names, these must be reinterpreted in order to fit the above characterization; namely, they must be understood as propositions *about* symbols, and hence indirectly as propositions about those individuals which are replicas of the symbols. For example, "*A* is *A*" means that if replicas of the same name be brought before and after any replica of the rhematic symbol of identity, the result will be a replica of a true proposition. Similar treatment is possible for propositions having abstract subjects, "redness," "justice," etc. By the admission of a complex of individuals as a single existent object, PEIRCE eliminates the difficulties which are encountered by the traditional subject-predicate doctrine in the treatment of relations. The subject of "Cain kills Abel" is the dyad of Cain and Abel, in that order. This dyad is a mental diagram representing the pair of Cain and Abel in an ordinal fashion; the pair itself, as orderless, is construed as a single existent object characterized by being dependent, for its existence, solely upon the joint existences of Cain and Abel.

PEIRCE regards hypothetical propositions as embracing all propositions. He construes the categorical proposition as a "formal implication," to use the language of *Principia Mathematica*: "all *A* is *B*" means "if *A*-hood then *B*-hood," or in other words "for every x, if x is an *A* then x is a *B*." A negation is an infinitely iterated hypothetical; "not p," where p is a proposition, means "p implies that p implies that p implies that..." without end. If we take implication in the material sense, the justness of this treatment of negation is obvious; just as the material implication $p \supset q$ is equivalent to "not p or q," so

$p. \supset :. p. \supset : p. \supset ....$ is equivalent to " not p or not p or not p or..." As to conjunction and disjunction, the reader of *Principia Mathematica* knows that these are easily expressed in terms of material implication and negation. Having thus made hypothetical propositions all-inclusive, PEIRCE proceeds to indicate an interesting relation among rhemes, propositions (or dicent symbols) and arguments (or suadisigns). The argument has the form " p; $\therefore$ q. " If we cease to assert premiss and conclusion, it reduces to the hypothetical proposition, that is to say simply to the proposition, " if p then q." A proposition may in turn be simplified into a rheme, by depriving the former of its content; this is done by introducing blanks in lieu of one or more constants.

PEIRCE's effort to give all propositions the hypothetical form is of a Procrustean character at best. The definition of negation in terms of infinitely iterated implication is a grotesque case of the explanation of the familiar in terms of the unheard of. This device does not serve to reduce his primitive notions to one, namely implication, for in the notion of the infinite iteration of an operation we have a second rather appalling primitive. In a word, implication, like disjunction, conjunction and negation, is inadequate as a sole fundamental logical operation; what PEIRCE seems to have hoped for from the notion of implication is actually yielded by the notion of material incompatibility, as has been brought out by Prof. H. M. SHEFFER's work (2) in later years. As to the treatment of the categorical, it can only be said that PEIRCE does not succeed in identifying this with the hypothetical *simpliciter*, but rather with the result of universally quantifying a hypothetical. The burden of treating quantification still remains, and this cannot be disposed of in terms of the notion of hypothetical proposition (3). PEIRCE describes universal and particular quantification as precepts directing the second person and the first, respectively, to select the subject of the proposition —an acute observation, but extra-formal. Finally, it is obviously impossible to construe all propositions as *fundamentally* hypothetical. For, not only would p be hypothetical, but the antecedent and consequent of p would in turn be hypothetical, and so also their antecedents and consequents, and so on *ad infinitum;* we should have an infinite regress of implications, but never any ultimate antecedents or consequents, never any content. At best, therefore, the hypothetical form can only

(2) *Trans. Amer. Math. Soc.*, Vol. XIV, pp. 481-488.

(3) It might be remarked that, if PEIRCE is to use the notion of universal quantification as a primitive accessory to material implication, he might with its aid define negation without recourse to infinite iteration of implication. Namely, " not p " could be defined as meaning " for every proposition q, $p \supset q$. " alternatively, " if p, then, for every q, q."

be regarded as a form which *may* be applied to any proposition, albeit with an increase of complexity.

The department of inquiry which PEIRCE institutes in these pages, namely the theory of signs, is a field of great importance for epistemology and logic alike. When we deal with the relations of signs to their objects, we are concerned with the whole machinery, not only of communication, but of conceptualization, in its relation to the qualitative content of crude experience. That important consequences of the scientific classification and analysis of signs may be expected to redound to logic as well, is witnessed by the fact that such inquiry has resulted in a doctrine of propositions and propositional functions within the pages under consideration. Through some such medium as this, furthermore, we may expect light to be shed upon those problems, quasi-logical and quasi-philosophical, which deal with the relations which an abstract calculus or postulate system, written wholly in terms of unassigned variables, bears to the many sets of definite concepts with which those variables may variously be identified.

The work which PEIRCE presents relative to the theory of signs must, however, be regarded as the first rather than the last word. Even if his general outline should stand, no end of detailed development remains to be supplied. *Primâ facie*, PEIRCE's classification of signs seems important and fairly fundamental; their pragmatic test can only come, however, with the erection of a superstructure of detail. The theory of propositions which PEIRCE derives is not altogether satisfactory. We have seen it to be a highly extensionalist view, demanding that all propositions be interpreted ultimately in terms of propositions whose subjects are specific individuals. Propositions with abstract subjects have to be paraphrased to conform; propositions whose terms are general become interpreted through quantification as convenient ways of enunciating sheafs of propositions whose respective subjects are individuals. Such a manner of analysis points in the wrong direction. It means bundling off all notions of generality, all grounds for association of individuals, into the notion of quantification, and interpreting the latter preceptually. Instead of propositions relating general terms, we have the less clear notion of propositions relating undetermined individuals. Rather does the more expedient mode of approach seem to be just the reverse, namely to regard a quantified proposition such as " for all x, if x is an A then x is a B," or more briefly and generally " for all x, ϕx," as a proposition predicating uniersality of a definite ϕ; PEIRCE would regard it as predicating ϕ of an indefinite x, namely whatever x the listener might propose. Such matters might, however, admit of adjustment to the general satisfaction without modification of the broader outlines of PEIRCE's theory of signs.

Book III, which is made up almost wholly of reprints, is devoted to inference. " Every inference " PEIRCE writes, " involves the judgment that, if *such* propositions as the premisses are true, then a proposition related to them, as the conclusion is, must be, or is likely to be, true. The principle implied in this judgment... is termed the *leading principle* of the argument. A *valid* argument is one whose leading principle is true." Rather than countenancing " suppressed premisses," PEIRCE construes all such suppressed material as entering the leading principle. There are principles which cannot be eliminated from a leading principle, no matter how we augment the premisses. These he terms *logical* principles. This point is an important one; it seems closely related to what Prof. C. I. LEWIS (4) has in mind in speaking of the circularity of logic. A logical principle must be retained as a leading principle even though it be repeated in the premisses.

Like KANT (5), PEIRCE bases syllogistic reasoning upon the subsumption of a case under a rule. In the first figure the rule (major premiss) is asserted, a case (the minor premiss) is subsumed under it, and the result is inferred. The second figure proceeds by asserting the rule and denying the result, thus eventuating with denial of the case. In the third figure the result is denied and the case asserted, the rule thus being denied in the conclusion. PEIRCE arrives at the immediate inferences by identifying the major or minor term with the middle term, in an ordinary syllogism, and then relegating to the leading principle that premiss which becomes trivial (such as " all M is M ").

Pointing out that ordinary syllogistic supposes an unlimited universe of characters, so that every aggregate of things short of the universe has some character in common, PEIRCE proceeds to examine the logic of the situation where, as in ordinary discourse, the universe of characters is limited. When this limitation is imposed, the distinction between classes of things and groups of characters becomes factual; one-one correlation is no longer guaranteed. PEIRCE thus arrives at propositions of such form as " Some S has every Θ," where Θ is a group of characters. From such propositions he develops a syllogistic each figure of which comprehends nineteen species of syllogisms, while each species has thirty-two or sixty-four different moods. Otiose as the traditional syllogistic appears in the light of modern symbolic methods, it is difficult to detect any justification, other than caricature, for the hundredfold more cumbersome syllogistic just now described.

It is in the portion of Book III dealing with probable inference that

(4) *Mind and the World Order*, pp. 207 *sqq*.
(5) *Critik der reinen Vernunft*, 1st ed., p. 304.

we find PEIRCE at his best. The bulk of this material is reprinted from *Popular Science Monthly* and the Johns Hopkins *Studies in Logic*, and has already been collected in the volume *Chance, Love and Logic* (ed. MORRIS COHEN). Peirce makes a distinction between *induction* and *abduction* (or *hypothesis*) which is expressed by the following comparison. Deductions of the first figure have the form: Rule, Case, ∴ Result. Inductions take the form: Case, Result, ∴ Rule. Adbuction has the form: Rule, Result, ∴ Case. In another scheme PEIRCE admits *probable deduction*, corresponding to the first figure of apodictic deduction. For example, in *Barbara*,

Rule: Most M are A
Case: All B are M
∴ Result: Probably, most B are A.

He then shows induction and abduction to correspond respectively to the other two figures; induction and abduction are apagogical transformations of probable deduction. "The great difference between induction and hypothesis," he writes, "is that the former infers the existence of phenomena such as we have observed in cases which are similar, while hypothesis supposes something of a different kind from what we have directly observed, and frequently something which it would be impossible for us to observe directly." At a later point he characterizes induction, abduction and deduction (certain or probable) as occupied respectively with the discovery of laws, the discovery of causes, and the prediction of effects. Induction and abduction constitute *ampliative* reasoning. In valid deductive reasoning, even though it be of the probable variety, the result will in the long run tend to be *vindicated*; in valid ampliative reasoning the result will tend in the long run to be continually *modified* in the direction of the truth.

"*Probability*... is the ratio of the number of arguments of a certain genus which carry truth with them to the total number of arguments of that genus." PEIRCE treats the addition of probabilities in the usual manner, but finds that the usual rule for their multiplication calls for a restriction. Let A, B and C be classes of propositions, and let a, b and c be propositional variables the ranges of whose values are respectively A, B and C. According to the usual rule, where m and n are the respective probabilities of "if a then b" and "if b then c," $m \times n$ is the probability of "if a then c." PEIRCE points out, however, that this result may be interfered with if there is a considerable subclass B' of B each member of which follows from many members of A, while no member of C follows from any member of B'.

We see that for PEIRCE probability is objective—a ratio between classes, dependent upon fact rather than knowledge. An occurrence has no

probability in isolation, but only as one of a class considered in reference to another class. He inveighs against the conceptualist point of view, according to which an event has a probability without reference to classes of events, that probability being a function of our ignorance and measured by our grounds for belief in the event. A consequence of the latter view is that complete ignorance regarding an event gives the latter a probability of $\frac{1}{2}$. The absurdity then arises, by the law of addition of probabilities, that the probability of the disjunction of any two mutually independent possibles x and y would be 1 or *certainty* provided only that we be completely ignorant concerning them. PEIRCE also shows it to follow that all reasoning from past to future would be worthless. Since on the other hand probability is for PEIRCE objective, complete ignorance means for him indeterminate, rather than neutral, probability. PEIRCE does, however, countenance a correlation between probability and justified belief. This is expressed in terms of *chance*, which may be defined in terms of probability (p) as $\frac{p}{1-p}$. PEIRCE's tentative law, which is an analogue or an aspect of FECHNER's psychophysical law, is that intensity of belief is, ideally, proportional to the logarithm of the chance.

The formal condition of the validity of an ampliative argument is the validity of the probable inductive syllogism of which, as mentioned earlier, the former is an apagogical transformation. PEIRCE recognizes the necessity, however, of supplementing this formal rule with two practical canons governing its application as well as governing the probable deduction to which the rule refers. First, the sampling of instances must be random, or, failing this, the derived probability must be modified mathematically in recognition of the confinement of samples to a predetermined subclass. The second canon, whose importance PEIRCE demonstrates by skillful adduction of examples, is that the characters in point of which the samples are to be examined must be designated in advance of the sampling.

Even from the present meager summary, the importance of PEIRCE's two cardinal points regarding probable inference is manifest: reference is had first to the sharp distinction between induction and abduction, and second to the interpretation of probability as a ratio of species of arguments. The first serves not only to crystallize a distinction whereof men tended hitherto to be vaguely and less articulately aware, but furthermore it results, as we have seen, in an interesting correlation of ampliative reasoning with the traditional figures of deductive syllogistic. As to the second cardinal point mentioned, this seems to penetrate to the roots of probability theory, with a salutary effect upon much nonsense that

has been thought and uttered regarding the nature of probability. Moving to PEIRCE's more special contributions, such as the second canon of probable inference, and the exception to the multiplication of probabilities, both set forth above, we find a skillful exposé of pseudo-scientific method. In such matters as the logarithmic law of belief, on the other hand, while finding nothing definitely exceptionable or untenable, one yet senses an unmistakeable drift toward the fanciful. At other points, not deemed justificatory of especial treatment above, this tendency is more pronounced; it culminates in an essay which an unsympathetic reviewer might too baldly describe as advancing the thesis that the fundamental presuppositions of logic are Faith, Hope and Charity.

The volume as a whole was a forbidding editorial task; for the same reasons it is, to a lesser degree, a task for the reader. The miscellaneous and fragmentary character of much of the material makes its organization into a smooth and systematic development impossible, although the editors are to be praised for having been partially successful in that direction. Abundant intermediate digressions remain, as also do countless cases of slightly modified repetitions from article to article; such is unavoidable without an unjustified maceration of the fragments themselves. As to the content, the present survey is intended to suggest that, while there is considerable dross, there is much gold; the proportion of the two could be far less favorable than it is and still leave a perusal of the volume amply rewarded. It is to be remembered in the late author's defense that he was not present to insist upon the exclusion of various hitherto unpublished manuscripts.

Harvard University.

W. V. QUINE.

G. Loria. — *Il Passato e il Presente delle Principali Teorie Geometriche. Storie e Bibliografia.* Quarta edizione totalmente rifatta. Padua, CEDAM, 1931. XXIII + 467 p.

The first edition of this work appeared in *Memorie della reale Accademia delle Scienze di Torino*, s. 2, v. 38, 1887, p. 327-376. A German edition by F. SCHÜTTE, with numerous improvements and additions by LORIA, appeared (1) in 1888. A Polish edition by S. DICKSTEIN, with additions by the author and translator, was published (2) in 1889.

The second Italian edition, " accresciuta ed interamente rifatta," was

(1) *Die hauptsächlichsten Theorien der Geometrie in ihrer früheren und heutigen Entwickelung*, Leipzig, VI + 132 p.

(2) *Przeszlość i stan obecny najważnicjszych teoryj geometrycznych.* Warsaw, VIII + 112 p.

published in book form (3) in 1897. Of this edition the first chapter was translated into English by G. B. HALSTED (4).

The third Italian edition, increased by an appendix, "sguardo allo sviluppo della geometria in quest'ultimo decennio," came out ten years later (5). And now, nearly twenty-five years after the appearance of the first edition, we have still another greatly revised edition.

In comparing this fourth edition with the third, one finds that the first eleven chapters have the same titles but that the twelfth chapter of the third edition is now called "Raccogliendo i dispersi." The eleven chapters had headings 1. "Sketch of the origin and development prior to 1850," 2. "Theory of plane algebraic curves," 3. "Theory of algebraic surfaces," 4. "Theory of algebraic curves of double curvature," 5. "Differential geometry," 6. "Inquiry into the form of curves, surfaces, and other geometrical figures. Analysis situs. Configurations," 7. "Geometry of the line in space," 8. "Correspondence, representation, transformation," 9. "Enumerative geometry," 10. "Non-euclidean geometry," 11. "Geometry of space of n-dimensions." The appendix of the third edition is transformed, in the fourth edition, into book II, (chapters 13-15) on "The progress of geometry during the last thirty years."

Such surveys as that of Professor LORIA are certainly of extraordinary usefulness. Enormous developments in geometry have taken place since the *Aperçu historique* of CHASLES in 1837 or even since KÖTTER's work "Die Entwickelung der synthetischen Geometrie von MONGE bis auf STAUDT (1887)" (6). Some suggestions in this direction may be found in the two geometry volumes of the second German edition of PASCAL's *Repertorium der höheren Mathematik*, 1910-22, but many more are indicated in the huge survey by various authors, including Professor LORIA, of the *Encyklopädie der mathematischen Wissenschaften*, 1907-31, which fills already nearly 4500 pages. (7) A very notable American supplement to one part of this *Encyklopädie* is the report on *Selected Topics in Algebraic Geometry* (Washington, D.C., 1928. 395 p.) by a Committee on Rational Transformations, of which Professor VIRGIL SNYDER is chairman.

Another survey work of a very different character, in the elementary

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(3) Turin. XX + 346 p.

(4) "Sketch of the origin and development of geometry prior to 1850," *The Monist*, v. 13, p. 80-102 (Oct. 1902) and p. 218-234 (Jan. 1903).

(5) Turin, 1907. XXIII + 475 p.

(6) Jahresh. d. deutschen Mathematiker-Ver., v. 5, 1901, 28 + 486 p.

(7) About 1000 pages of the French edition, *Encyclopédie*, were published 1911-15.

field, is MAX SIMON's *Über die Entwicklung der Elementar-Geometrie in XIX Jahrhundert* (Leipzig, 1906. VIII + 278 p.) which was the first of a series of Ergänzungsbände published by the Deutsche Mathematiker-Vereinigung. In one respect this volume immediately achieved a unique distinction in that it probably contained more typographical and other careless errors than any mathematical work from a reputable source published up to that time. In this respect Professor LORIA's work is not quite as bad but the number of desirable changes (rarely serious, 'tis true) may easily run into thousands.

But we are indeed grateful to Professor LORIA for his valuable new survey, and especially for that part of it which treats of the progress of geometry during the past thirty years. Gaps in the information may readily be found, even in connection with important results published five or six years before the date of the volume. But such things are to be expected in the case of any great undertaking of this kind, carried through by a single individual.

R. C. ARCHIBALD.

G. Loria.—*Storia delle matematiche. Volume* 2, I *secoli XVI e XVII.* 595 p. Turin, STEN, 1931. Price 25 lire, bound.

This volume contains chapters 16-30 of the history begun in 1929; each chapter concludes with a good bibliography. The first two chapters (p. 21-130) deal in an interesting manner with algebraic achievements of Italy and the outside world. The next chapter discussing humanism and its influence on mathematical study is followed by one on trigonometry and circle-squaring in the sixteenth century. In chapter 20 the influence of scientific correspondence, printing of periodicals, scientific academies and societies, as auxiliaries to scientific research, are described. " First years of a glorious century " is the title of the next chapter when the work of such men as NAPIER, BÜRGI, GALILEO GALILEI, KEPLER, BACHET DE MÉZIRIAC is discussed. Then follow chapters on Disciples of GALILEO (CAVALIERI, TORRICELLI, VIVIANI, etc.), on Algebraists (GIRARD, HARRIOT, OUGHTRED, and HÉRIGONE), and on the beginning of modern mathematics with DESCARTES and FERMAT. Chapter 25 deals with the revival of pure geometry in the work of DESARGUES and PASCAL, and 26 with precursors of the infinitesimal calculus. The last three chapters (p. 475-582) are taken up with the origin of the calculus, the work of NEWTON and LEIBNIZ, and their relation to one another.

The history is written in a new, and very pleasant, and clearly articulated form, with interesting and suggestive emphasis, and is heartily recommended to all interested in mathematical history.

R. C. ARCHIBALD.

XUM

Francisco Vera.—*Historia de la matemática en España.* 1. *Tempos primitivos hasta el siglo XIII*, 309 p. 2. *Los precursores del renacimiento siglos XIII, XIV y XV.* 509 p. Madrid, SUÁREZ, 1929 and 1931.

These are the first two volumes of a seven-volume, small-page (11 × 16 cm.) work of which the first two are listed as numbers 8 and 10 in the popular series "Biblioteca Española de Divulgación Científica." These are the first mathematical volumes in the series. It is planned that there shall be five more volumes of the *Historia* of which the next two are to be, 3. Los árabes (siglos VIII al XVI), 4. El Renacimiento (siglo XVI); it will be recalled that in 1913 Professor J. REY PASTOR published an admirable volume entitled *Los Matemáticos Españoles del Siglo XVI.* The remaining volumes are to be, 5. La decadencia (XVII y XVIII), 6. Epoca moderna (siglo XIX), and 7. Los contemporáneos (siglo XX).

Mr. FRANCISCO VERA's name has been a familiar one in both scientific and literary circles for a score of years, and more than a dozen works have issued from his pen, since the first published at Madrid in 1909, on *Teoría general de Ecuaciones.* Among his other mathematical works is a practical arithmetic and geometry (1911), the first volume of a general course of mathematics (1926), and one on space, hyperspace and time (1929). His style is pleasantly fluent.

In the volumes under review the setting of the beginnings of Spanish mathematics with reference to the general history of mathematics, and the history of the country, are set forth in a form highly appropriate for the series; but it is also well documented with some seventy pages of full titles of works consulted, lists especially valuable for one not very familiar with the field, or for the librarian desiring to secure representative works in the field.

By the tenth century Cordova was becoming an intellectual center for Islam and about this time there were a number of scholars writing on such topics as amicable numbers, arithmetic, astronomy, geometry, algebra, and astronomical tables and instruments.

The eleventh century saw a considerable influx of Moorish scholars into Spain and they contributed to mathematics. But the most noted Spanish scholars of the eleventh and twelfth centuries were Jewish. One of these, ABRAHAM BAR CHIIA, commonly known as SAVASORDA, was a native of Barcelona and his *Liber Embadorum* treating especially of geometry is of particular interest in the period. Another Hebrew scholar, the most learned Jew of his time, was RABBI BEN EZRA who was born at Toledo, and wrote in an able manner on a variety of mathematical topics. But of them our author does not treat. He has chapters

on medieval Spanish cartography and mathematical teachings in the Universities.

All those interested in the history of mathematics will applaud Mr. FRANCISCO VERA for supplying such a comprehensive account of his country's mathematical activities.

R. C. ARCHIBALD.

Gaston Bachelard. — *Le pluralisme cohérent de la chimie moderne.* 235 p., Paris, VRIN, 1932. (Fr. 25)

Les ouvrages si instructifs de M. BACHELARD se prètent mal à l'analyse et ne peuvent être résumés sans être aussi déformés ; loin, en effet d'apporter une thèse toute faite, dogmatique et victorieuse, que les faits expérimentaux aussi bien que les doctrines scientifiques viennent, sur l'ordre d'un habile avocat, appuyer, corroborer, illustrer et même imposer, l'auteur offre simplement les résultats d'un travail d'exploration ou d'approfondissement progressif des diverses théories fécondes proposées par les savants ; le livre qu'il vient de publier ne contient à proprement parler ni une histoire de la chimie, ni une philosophie chimique, mais plutôt une série de considérations basées sur une connaissance solide de cette histoire et de cette philosophie; et ces considérations, en ouvrant à notre méditation quelques perspectives nouvelles, permettent de mieux pénétrer, et la structure de la science et la structure de l'esprit qui, par un effort continu, est parvenu à créer cette science.

Nous ne pouvons donc songer à suivre pas à pas l'argumentation de M. BACHELARD qui, délaissant la science appliquée et toute proche de l'empirisme et qui se fait dans le laboratoire de l'ingénieur chimiste ou du pharmacien, s'attache surtout aux hypothèses fondamentales concernant les soubassements du monde matériel ; s'il n'étudie l'évolution de la théorie qu'à partir du XVIII^{e} siècle, c'est que l'on n'est parvenu qu'alors à percer « la diversité qui se joue à la surface du phénomène » pour atteindre enfin une diversité moins fuyante, moins fugace, plus essentielle et plus profonde. La composition supposée des corps était jusqu'alors plus " *étymologique* " qu'expérimentale, ou comme l'a dit excellemment CHEVREUL, la science a confondu jusqu'à l'époque de LAVOISIER l'analyse mentale avec l'analyse chimique. Mais alors la chimie est devenue substantialiste ; du moins elle a voulu d'abord extraire les éléments des combinaisons et recréer les combinaisons primitives en faisant réagir ces éléments ; puis la chimie a progressé en découvrant des corps simples ou en produisant de nouveaux corps composés ; la théorie pourtant aurait risqué d'être plus encombrée qu'enrichie par cet amas énorme de matières disparates, si elle n'avait fait effort pour dominer les innombrables matériaux apportés par l'expérience. Elle a

XUM

tenté d'utiliser ces matériaux pour construire un monument harmonieux ; et les vicissitudes de cette construction ont guidé, parfois même impérieusement commandé, les recherches de l'expérimentateur ; la plupart des historiens de la chimie se sont appliqués à mettre en valeur les découvertes, laissant un peu dans l'ombre les travaux des architectes que M. BACHELARD s'est efforcé de dégager en pleine lumière. En étudiant la pensée du chimiste et son mouvement de va et vient de la théorie en formation perpétuelle à l'expérience de plus en plus fine, il a dégagé le jeu dialectique de deux idées philosophiques ; car cette pensée lui « paraît osciller entre le pluralisme d'une part et la réduction de la pluralité d'autre part » ; et ce jeu dialectique et progressif s'est poursuivi dans la classification des substances de la chimie organique, laquelle est parvenue, sur l'ordre de la théorie, à produire une multitude de corps que la nature ne nous avait pas offerts spontanément; il s'est poursuivi dans le rapprochement des corps simples, qui, parti des familles d'éléments de J. B. DUMAS, a abouti aux classifications périodiques de LOTHAR MEYER et MENDELEEF. Le tableau de MENDELEEF d'ailleurs, que certains praticiens ont pu considérer comme une élégante et stérile vue de l'esprit, n'a pas tardé à prouver sa valeur théorique non seulement en faisant comprendre le présent, mais en engageant et prophétisant l'avenir, provoquant de nouvelles recherches et d'admirables découvertes ; s'il est vrai « qu'on ne demande pas à une vue générale d'être étendue, on lui demande d'être extensible » le tableau de MENDELEEF a montré à ce point de vue une fécondité qui est loin d'être épuisée.

M. BACHELARD a enfin pénétré dans les problèmes qui sont encore aujourd'hui objet de recherche et de discussion pour les théoriciens de la chimie ; la structure de la matière, l'analyse spectrale, la description quantique, la prise de possession de la diversité matérielle par les mathématiques. Par ce dernier effort, la doctrine chimique a pu réduire la diversité du donné tout en respectant cette diversité, et sans la proclamer apparente seulement ou illusoire ; elle est parvenue par un travail de construction à rendre cohérent le pluralisme des substances sur lesquelles elle opère ; car bien qu'il soit faux « que le règne de la quantité et de la mesure surmonte à jamais le règne de la qualité », il est vrai que là où la qualité s'ordonne, les mathématiques modernes, qui sont autant la science de l'ordre que du nombre, trouvent à s'appliquer, sans chercher à détruire ou à anéantir cette qualité. Et ainsi « dans la science contemporaine se dessine le panorama mathématique de la matière ».

Nous n'avons pu, dans ce trop bref compte rendu, donner une idée de la richesse suggestive de la pensée de M. BACHELARD qui est proprement inépuisable et qui appellerait souvent des commentaires plus étendus que le texte même de l'auteur ; nous aimerions discuter du point

de vue historique certaines assertions concernant BAUMÉ et la chimie du XVIII^e siècle ; nous aimerions discuter du point de vue philosophique les opinions de M. BACHELARD concernant le rôle scientifique de l'analyse et de la synthèse ; enfin nous souhaiterions que certaines indications écrites en passant, et rapidement, soient objet de développement dans un prochain ouvrage, car elles pourraient projeter de nouvelles clartés sur la science et son évolution ; témoin cette remarque lourde de sens historique : « C'est un fait épistémologique très curieux qu'on n'arrive pas à organiser ensemble deux approximations d'ordre nettement différent, encore que ces approximations étudient le même phénomène ».

H. METZGER.

F. **Marguet.**—*Histoire de la navigation du XV^e au XX^e siècle.* 301 p. ill., Paris, Société d'éditions géographiques, maritimes et coloniales, 1931.

Les premiers chapitres de cet ouvrage, qui est plutôt une histoire de l'art de naviguer qu'une histoire de la navigation — il n'y est pas question du navire, qui joue cependant un certain rôle dans la navigation, ni de la connaissance des courants marins, des vents — constituent une nouvelle édition très étendue de l' « Histoire de la longitude à la mer au XVIII^e siècle en France » (*Isis*, 4, 152).

L'auteur y expose ce qui a été fait pour se diriger sur mer à partir de la fin du XV^e siècle. L'histoire de la longitude l'amène à retracer les différentes étapes par lesquelles a passé le « problème du point ».

Les grands voyages en haute mer ne sont vraiment entrés dans la pratique de la navigation qu'aux environs de l'an 1500. Pour abréger leurs voyages, il fallait que les marins soient capables de déterminer à chaque instant leur position en mer, et qu'ils aient à leur usage des cartes côtières et océaniques exactes. Jusqu'à la fin du XVIII^e siècle, la presque totalité des grands voyages s'est faite avec les seuls procédés de « l'estime ». La navigation à l'estime exige un instrument d'orientation et un autre pour mesurer la vitesse, puis elle pose un problème de géométrie pure qui consiste à déterminer sur le globe terrestre le chemin suivi.

Longtemps, les instruments furent imparfaits, et les marins niaient la déclinaison de l'aiguille aimantée : le mathématicien espagnol MEDINA nie encore l'existence de la déclinaison en 1545. Les problèmes que pose la boussole furent l'objet de travaux considérables ; la rose à aiguilles multiples aimantées date de 1773, et est due au danois LONS.

La question de la déclinaison n'intéresse pas seulement l'estime, elle est directement liée à la détermination de la longitude. En 1603, GUILLAUME LE NAUTONNIER publie un énorme ouvrage intitulé « La

mécométrie de l'Eymant ou l'art de trouver la longitude par la déclinaison de l'Eymant », où il annonce que l'aimant « montre le chemin qu'on a à tenir au milieu de la mer ». A la fin du XVII^e siècle, la question est reprise par E. HALLEY, à la suite de longs voyages qu'il a faits dans l'Atlantique : il publie une carte sur laquelle étaient tracés les méridiens magnétiques pour l'année 1700, carte parfois très erronnée que corrigent MOUNTAIN et DODSON pour 1744 et 1756, BOUGUER pour 1753.

Le tracé de la route suivie par le navire est d'abord étudié par PEDRO NUNES qui en 1556 découvre un tracé approximatif ; en 1569, MERCATOR publie sa carte fameuse et annonce que ce tracé se réduit à une ligne droite de même orientation que la courbe de la terre. Il a fallu les travaux de H. BOND (1645), de E. WRIGHT (1657), J. GREGORY (1668), E. HALLEY (1695, solution du problème de la loxodromie), et les immenses progrès des mathématiques pour en finir avec ce problème. La cartographie supportait les mêmes erreurs que l'estime.

Les marins déterminaient, plutôt mal que bien, la latitude avec des instruments tels que l'astrolabe, l'anneau astronomique, le bâton de Jacob. C'est à CHRISTOPHE COLOMB qui, lors de son premier voyage fit le point très soigneusement, que revient la découverte de la variation de la déclinaison avec le lieu.

Les tentatives pour obtenir la longitude par la boussole ou les satellites de Jupiter ne devaient pas aboutir : il fallait des montres et des tables lunaires. Dans la seconde moitié du XVII^e siècle, grâce à CHRISTIAAN HUYGENS qui, en 1656, emploie le pendule et le ressort spiral comme régulateur des horloges, on peut perfectionner les machines à mesurer le temps. SULLY trouve au début du XVIII^e siècle le moyen de diminuer les frottements. JOHN HARRISON cherche pendant quarante ans à perfectionner l'horloge marine et construit vers 1760 une montre compliquée exceptionnellement réussie. JULIEN LE ROY, élève de SULLY, donne un grand essor à l'horlogerie, et son fils PIERRE réalise enfin (1766) l'horlogerie de précision avec des principes qui sont ceux sur lesquels on construit encore actuellement le chronomètre ; pendant que FERDINAND BERTHOUD établit en 1763 la montre portative.

Mais le chronomètre ne suffit pas. Le problème de la longitude doit être résolu par l'astronomie. A la mer, il faut avoir de bonnes tables de la lune ; les premières tables vraiment utiles sont celles de TOBIAS MAYER (première édition 1753) ; celles de BOUVARD (1800), de BURG (1800-1802), de BURKHARDT (1811) leur sont naturellement très supérieures ; celles de HANSEN (1862) servent encore à la *Connaissance des temps*.

Les tables permettaient de prédire les positions de la lune pour un temps déterminé, le temps de Paris par exemple. Pour trouver en un lieu ce temps de Paris correspondant à une heure locale donnée, il reste

par conséquent à déterminer en ce lieu, par l'observation, la situation de la lune sur la sphère céleste ; ce sont les instruments de HOOKE, l'octant de NEWTON, les instruments de HADLEY, de CALEB SMITH, de THOMAS GODFREY, de DE FOUCHY, de BORDA, de ROWLAND, etc., qui, de perfectionnements en perfectionnements, permettent cette détermination.

L'amélioration des instruments de mesure a eu comme conséquence un perfectionnement des procédés de calcul. Et de progrès en progrès, tant techniques qu'astronomiques et purement mathématiques, sort la solution du problème de la longitude.

Ce problème résolu, la navigation devient facile. L'océan Pacifique, par exemple, est parcouru en tous sens, sa carte est dressée.

A l'heure actuelle, les ressources qu'apportent le compas gyrostatique, la télégraphie sans fil, ouvrent peut-être aux méthodes de navigation une ère nouvelle.

L'ouvrage de MARGUET est très technique, un peu confus, il manque malheureusement de références bibliographiques ; son index alphabétique est incomplet.

Je rappelle que F. MARGUET, professeur d'astronomie à l'école navale (*Isis*, 1, 176 ; 3, 106, 118, 134 ; 4, 152 ; 8, 162) a obtenu le prix Binoux en 1915, en même temps que G. SARTON et A. ANTHIAUME.

L. SAPIN.

Haldór Hermannsson. — *The Cartography of Iceland* (= Islandica, Vol. XXI), 81 p., 27 plates. Cornell University Library, Ithaca, N. Y. London, Humphrey Milford, Oxford University Press, 1931.

Five years ago Prof. HERMANNSSON published in the same series a monograph entitled " Two Cartographers : GUDBRANDUR THORLÁKSSON and THÓRDUR THORLÁKSSON " in which he showed that the work of these man marked an epoch in the Cartography of Iceland " from its first appearance in 1585 down to the middle of the eighteenth century."

The present work is a survey of the whole field—with the exception of the period previously treated—from the beginnings in the 11th century down to the end of the 19th century.

This survey falls in two main parts, the first deals with " Iceland on Medieval Maps and Portolan Charts and Sailing Directions," the latter treats the " Maps of the Eighteenth and Nineteenth Centuries." The progress in mapmaking is shown in 26 plates representing the chief types.

Since TH. THORODDSEN wrote " Landfraedissaga Íslands " not much has been done in this field and never before has the cartography been the sole object of study. HERMANNSSON duly acknowledges his duty to THORODDSEN in the words (p. 77) " his works are indispensable to any one interested in those subjects, as the frequent references in the

present essay show". It is true that these references are rather numerous in the second part of the essay, but that cannot be said about the first part, which is really a very original study in a vast and widely scattered material. One gets an idea of the difficulties when reading on p. 3 that " there are hundreds of portolan charts in exitence, and it has been estimated that there are about one hundred antedating 1500. Comparatively few have been published, and as they are scattered all over Europe and America in various public and private libraries, it would be difficult to consult them all. A complete survey would require visits to the places where they are, or dependable reproductions of all of them, but neither has been withing my reach."

It would lead too far afield here to trace even the main lines of this survey. It must suffice to note that the maps dealt with in the first part are chiefly of Italian, Spanish, Portugese, French, and Dutch origin. In these maps, fantastic as they often are, there are, however, discernible some traces of local knowledge, as e.g. in the Fixlands type originating in the middle of the 15th century and presumably based upon information from English sailors (Bristol), or the French Dieppe type appearing in the second quarter of the 16th century and based upon practical experiences of Breton sailors who at that time already had begun to frequent the rich fishing banks around Iceland.

If the Dutch maps from the 16th century are of small interest, so much the more is the value of their sailing directions or *leeskaarten* (reading maps) as they were called. The earliest of these date from 1566 and have been translated into Danish and English by ROBERT NORMAN in his " Safeguard of Sailors," London 1590.

These sailing directions contain a number of placenames; many are of Icelandic origin but not a few obviously foreign. HERMANNSSON prints these lists (there are two of them) in their English form (unfortunately the Dutch originals were not available to him) and comments upon the names. In most cases he has been able to identify them, if they are of Icelandic origin, or find a suitable place for them in the map, if they are of foreign origin. Still there are some names which he leaves unexplained and at least one case where I think he is definitely mistaken so I may perhaps be forgiven if I go here into detail.

We read p. 42 : " there is a Bay six leagues to the eastwards of the Rag (= Cap Horn or Cap Nord, HERM.) called Orgen Bay, and the easter point of that Bay is called Organ Point and that is the west point of a sound called Langerdall (= Húnaflói? HERM.) and within that sound is a harborough called Styngarffar (= Steingrímsfjördur? HERM.), and the East poynt of Langerdall is called Shell Nesse (= Skaginn (Skagatá?) HERM.)...

I think HERMANNSSON is right in all of his identifications here. Especially clear is the identification Styngarffer = Steingrímsfjördur. He does not attempt to find a place for Orgen Bay, and Organ Point, but obviously these places must be sought somewhere between Cap Nord and Steingrímsfjördur. Now I find on B. GUNNLAUGSSON's map a mountain called Orkin (= Örkin?) between Trékyllisvík and Reykjarfjördur. If that is Organ Point then Trékyllisvík is the O. Bay. This fits well in the sailing direction for the sailor must sail due SE from cap Nord to reach Organ Point, after which he has to turn almost due south into Húnaflói in order to enter Steingrímsfjördur on its west side.

When HERMANNSSON identifies Kiall Poynt with Gjögur to the east of Eyjafjördur he must be right, although no parallel to the name is to be found. But if so, Sound Kiall is Eyjafjördur. It is interesting to see that also in the first Sailing Direction Eyjafjördur is not represented by that name but by two others: Dackfort (Danish: Daeford) and Denfort (Danish: Dueford), obviously variations of the same name, whatever it was.

"... next sound Kiall is Flat (= Flatey? HERM.) and Flatstrand Bay (= Skjálfandi? HERM.)" Meant is, perhaps, the little bay at the mouth of Flateyjardalur, about which THORODDSEN in his "Lýsing Íslands" (I. 103-104) says: "ships can lay at anchor in Flateyjarsund and to the south of Víkurhöfdi when the wind is opportune."

"Item, from Watlingfer poynte to Sillie, the course is south west 15 leagues, and these are between them. Firste Rose Bay, next Southerfer, and then Redcliffe, ne(x)t Sillie and in the mouth of Sillie is an Island called Sillie."

HERMANNSSON is doubtless right in identifying Watlingfer (= Vopnafjördur) pointe with Kollumúli, Sillie with Seley, an island in the mouth of Reydarfjördur, and Southerfer with Seydisfjördur (older Seydarfjördur). Rose Bay would seem to be Héradsflói. But what is Redcliffe? To the south of Reydarfjördur there is a mountain, Reydarfjall, but that does not fit in the order, for Redcliffe is placed between Southerfer and Sillie. Perhaps this is a name for Bardsnes, the long rocky peninsula southeast of Nordfjördur. I have a hazy recollection that these rocks are of red hue and THORODDSEN (Lýsing Íslands I. 108) talks about the gaudy colors to be found in these rocks.

"Item, from Sillie to the Horn (= Vestrahorn, HERM.), the course is west southwest 30 leagues, and betweene them is firste Dofhouse, Rocke Bay, Prie Baye, Gooderwicke (= Breiddalsvík? HERM.) next Pappe Iland (= Papey, HERM.) which lyeth ½ league from the shore, and of Dofhouse (= Djúpavogur? HERM.) lyes a rock five leagues off the shore, called the Whales backe (= Hvalsbakur, HERM.)"

XUM

The identification Dofhouse = Djúpavogur is supported only by the last statement : THORODDSEN (Lýsing Íslands I. 117) also states that Hvalsbakur lies 5 miles (= leagues) off Berufjördur. Against that speaks, however, that it is named first after Sillie-Reydarfjördur and especially the following consideration. When HERMANNSSON identifies Gooderwicke with Breiddalswík, he is for the first time actually mistaken, Gooderwicke is obviously = Gautavík, a small inlet on the north side of Berufjördur rather far inland. I believe it is also meant by the name Godeneh (for Godeuek) on the map in Biblioth. Ambrosiana, Milan from ca. 1450 (Plate 5). JÓN ADILS says about it (Einokonarverslun Dana á Íslandi 1602-1787, p. 298) : " It was of old one of the chief harbours in the East and it is often mentioned in annals from the 14th and 15th centuries. Later on the Germans had there a commercial station, but in the latter half of the 16th century they moved to Fúlavík on the south side of the firth and later on to Djúpavogur (also on the south side of the firth), which after that became the home of the Danish monopoly merchants." It would seem from this even doubtful whether Djúpavogur was known at the time the sailing direction was written.

It remains to discuss the names Rocke Bay and Prie Bay.

I have little doubt that the former is = Faskrúdsfjördur, for outside the mouth of that firth lies the conspicuous rock Skrúdurinn, in fact the only island off the eastern shore deserving the name of a rock (see the picture in THORODDSEN's " Lýsing Íslands " I. 118).

Prie Bay might perhaps be connected with Breid-dals-vík the bay of the Broad valley (Dutch : Breede Bocht ?).

The Johns Hopkins University. STEFÁN EINARSSON.

Henri Bergson. — *Les deux sources de la morale et de la religion.* 348 p., Paris, ALCAN, 1932.

BERGSON semble bien apporter avec cet ouvrage, qui nous donne une morale et un mysticisme, le couronnement de son édifice philosophique. Celui-ci est représenté, en dehors d'importants articles de revues (notamment au *Bul. de la Société française de philosophie* et à la *Revue de métaphysique et de morale*), par les ouvrages suivants : *Essai sur les données immédiates de la conscience* (1889, une de ses deux thèses de doctorat, qui en est actuellement à sa 30e édition) ; *Matière et mémoire* (1896, essai sur la relation du corps à l'esprit) ; *Le rire* (1900, essai sur la signification du comique) ; *L'évolution créatrice* (1907, le centre de sa philosophie, maintenant à sa 39e édition) ; *L'énergie spirituelle* (1919, recueil d'essais et de conférences de nature surtout critique) ; *Durée et simultanéité*, à propos de la théorie d'EINSTEIN (1922).

Il est impossible de résumer en quelques lignes un ouvrage où l'expres-

sion de la pensée est déjà fortement condensée. Cependant, il faut dire ce que sont les deux sources de la morale. D'une part, l'individu appartient à la société qui, pour se maintenir, l'*oblige* à se subordonner au groupe et à servir l'idéal du groupe (il faut parce qu'il faut); mais d'autre part, l'élan vital pousse certains individus à se porter vers l'humanité en général dans un élan d'amour : la morale ne s'exprime plus alors par une pression, mais par une aspiration; à côté de la morale « close » qui est celle d'un individu et d'une société recourbés sur eux-mêmes, il y a une morale « ouverte » dont est constructif l'amour de l'humanité.

Quant à la religion, dont BERGSON voit l'origine dans ce qu'il appelle la « fonction fabulatrice » (création de fictions), et dans l'idée de la mort, on peut distinguer aussi une « religion statique », naturelle à l'homme, et une « religion dynamique », à qui la fonction fabulatrice ne suffit plus, et qui est mysticisme.

La dernière partie de l'ouvrage, intitulée « Mécanisme et mystique » nous donne la pensée de BERGSON sur l'avenir de l'humanité « à demi écrasée sous le poids des progrès qu'elle a faits ».

L. G.

Albert Bayet. — *La Morale de la Science.* 139 p. Paris, Les Presses Universitaires de France, 1931 (10 francs).

Il serait peu convenable de laisser dans l'ignorance de ce petit livre les lecteurs d'une revue placée sous le signe du nouvel humanisme, puisque aussi bien je crois pouvoir sans aucune ironie assurer qu'on découvrira dès les premières pages de ce mince volume une morale qui « égale ou passe en beauté toutes celles qui nous ont été offertes avant l'ère scientifique, et qui est également capable de discipliner nos vies et d'éveiller nos enthousiasmes ».

M. BAYET commence par remarquer que l'on reproche communément à la science l'immoralité de certaines de ses conséquences, atroces (tels nos modernes conflits armés) ou pénibles (chômage ; monotonie et manque de joie qui sont le fruit du machinisme) ; mais de cela, pas plus d'ailleurs que de ses bienfaits dans le domaine matériel, la science n'est pas l'auteur : elle n'est pas la complice de l'homme, mais sa victime ; il faut distinguer la science de ses applications, de la technique. Le meurtre (guerre) et la sottise ne sont pas son fait, mais le nôtre. L'utilisation que nous faisons de la science ne peut constituer une objection à son existence : « Dans une ville grecque attaquée, les défenseurs aux abois jetèrent sur les assaillants la statue d'un Dieu, et l'œuvre de beauté tua. Qui s'aviserait d'en conclure que l'art est homicide ? » La science donc n'est pas immorale. Elle n'est pas amorale non plus. Certes, « ni l'astronome ne juge l'étoile, ni le physicien n'exhorte l'atome ». La science « peut nous dire ce que sont

XUM

les idées morales des groupes humains et comment elles évoluent : elle ne peut nous dire ce qu'elles valent et ce qu'il faudrait qu'elles fussent» . Et M. BAYET fait ici à propos des travaux de M. LÉVY-BRUHL et de DURKHEIM des réflexions pertinentes sur la moralité de la science de la morale et de la science des faits moraux. Je me permettrai de lui reprocher de ne pas avoir rappelé que dans un chapitre des *Dernières Pensées* intitulé : « La morale et la science », HENRI POINCARÉ avait montré déjà que, pour une raison en quelque sorte purement grammaticale, « il ne peut pas y avoir de morale scientifique... Si les prémisses d'un syllogisme sont toutes les deux à l'indicatif, la conclusion sera également à l'indicatif » ; jamais on n'obtiendra en science « une proposition qui dira : fais ceci, ou ne fais pas cela ».

Mais considérons la science à l'état pur ; elle est dans ce cas uniquement compréhension et connaissance. Dès lors cependant, on constate qu'une éthique s'en dégage. Cet idéal dont la science est la source, « c'est l'ensemble des idées normatives qui ont engagé les hommes dans les voies de la recherche scientifique, qui en ont fait définir les méthodes, qui en ont assuré les progrès ». L'auteur s'attache à mettre en lumière cette morale strictement positive, qui à défaut de théoriciens a eu déjà ses artisans, et il la ramène aux quatre points suivants :

1) Le développement même de la science, c'est-à-dire son histoire, nous montre que « la dignité humaine consiste dans l'effort de l'esprit pour atteindre la vérité ». ARISTOTE a dit que rechercher la vérité, c'est courir après un oiseau qui s'envole ; de ce point de vue, la science apparaît plus grande. Cette curiosité obstinée, jamais lassée, qui est notre tourment, ce goût, cette passion impénitente de la recherche et de l'explication, confèrent à la science une dignité unique. L'astronomie apparaît — provisoirement du moins — comme la plus inutile de ces manifestations de notre souci de questionner la nature, et comme le plus ancien témoignage de notre activité connaissante, de cette inquiétude permanente qui est l'honneur, le seul sans doute, de l'homo sapiens. « Les religions et même les philosophies, soucieuses d'absolu, voudraient arrêter l'esprit sur des positions définitives », et par là (voyez les exemples de PASCAL et de COMTE) révèlent une tendance secrète vers cette inertie universelle dont on trouve partout la trace, puisque après tout — mais M. BAYET est muet sur ce point — l'état normal de l'humanité n'est pas l'état progressif, comme l'indique ce fait que nulle résistance n'est plus intuitive et inconsciente que celle qui se heurte au progrès scientifique, de tous les progrès le plus révolutionnaire. D'un côté, l'esprit se borne à la possession de vérités entières et définitives: c'est, prélude de la cristallisation et de la stagnation, le repos qu'offrent la religion et, dans une grande mesure, la philosophie. Mais il y a des insatiables, et c'est alors la chasse éperdue,

perpétuelle, aux vérités qui se dérobent : c'est l'idéal scientifique. Notre dignité réside donc uniquement dans l'accroissement de nos connaissances, dignité d'autant plus certaine qu'en revanche, comme ANATOLE FRANCE a eu le courage de l'écrire : « il n'est pas un peuple au monde qui ne soit souillé de tous les crimes et couvert de toutes les hontes ». N'entravons pas, ainsi que tels gouvernements pleins d'arrière-pensées, la diffusion du savoir. Favorisons-la au contraire ; c'est la plus humaine des tâches, bien qu'à présent l'affranchissement intellectuel dépende encore de l'affranchissement économique. Participons avec sympathie et joie aux débuts de l'Union Rationaliste.

2) En second lieu, l'activité scientifique implique l'union, c'est-à-dire qu'elle « se donne pour loi de faire en tous lieux l'accord des esprits ». Des religions, des philosophies ont poussé cette ambition jusqu'au fanatisme. Mais de ces ardeurs, de ces croisades, de ces luttes sauvages, que reste-t-il ? La bible vraiment commune aujourd'hui aux hommes des races civilisées, ce sont ces *Eléments* de géométrie compilés, il y a plus de deux mille ans, par un mathématicien de génie. « Il y a des savants catholiques, protestants, israélites, des savants anglais, allemands, français : il n'y a pas une géométrie catholique, protestante, israélite, une physique allemande, anglaise ou française, et la seule idée en est absurde ». Le premier rapprochement franco-allemand sincère et désintéressé après la guerre, ce fut la visite d'EINSTEIN à Paris. Pourquoi M. BAYET n'insiste-t-il pas ici sur le rôle que peut jouer l'enseignement de l'histoire de la science, dont ce n'est pas un des moindres mérites de montrer que le progrès scientifique n'est pas seulement l'œuvre de diverses nations, mais de civilisations radicalement différentes (cf. *Isis*, 6, 544-5) ? — Bien plus, « ces démonstrations exactes, ces vérifications laborieuses » qui constituent la science « sont la forme la plus haute de l'altruisme ». Elles révèlent en effet un désir d'accord basé sur quelque chose de plus fort que la force, l'intérêt ou le sentiment, elles fondent une union basée sur la vérité et la raison.

3) La création scientifique implique aussi le respect de la liberté de l'esprit. Le libre-examen est incompatible avec les dogmes religieux, intolérants par essence. « La science a les mains pures de tout sang versé ». Elle ne règne pas à coups de décrets, elle ne s'appuie pas sur la force, elle n'engendre ni haines, ni persécutions, car elle ne s'adresse qu'à la seule conviction. « C'est la grande originalité de la science d'être toujours restée étrangère à la malédiction comme à l'anathème, d'avoir pour loi la liberté », liberté indispensable, puisque notamment il ne peut y avoir de débat clos en science, celle-ci étant une évolution, un effort. Toutes les questions restent perpétuellement ouvertes, le principe d'autorité est ignoré. — La recherche implique même la sympathie qui accom-

pagne l'effort de compréhension ; comprendre, c'est presque toujours aimer. « L'esprit scientifique va au delà de la tolérance. Non seulement il répudie la haine ou le mépris comme étant une insulte à l'esprit : mais il les rejette d'abord comme étant un obstacle à l'intelligence ».

4) M. BAYET montre que dans le domaine de cette science naissante qu'est la sociologie « tout progrès du déterminisme sociologique entraînerait nécessairement, impliquerait une attitude de bienveillante indulgence à l'égard de tous les hommes », principe qu'on peut rapprocher de celui énoncé par GIDE lorsqu'il nous dit : ne jugez pas, efforcez-vous de comprendre. Le déterminisme sociologique nous enseigne aujourd'hui que les sociétés ont les criminels qu'elles méritent. — Cette bienveillance que nous suggère l'esprit de la sociologie s'applique évidemment aussi « à tous ceux qui, à l'ombre des lois, servent la cause de l'iniquité ».

Ces grands principes qu'implique l'activité scientifique se répandront peu à peu, au fur et à mesure que se diffusera l'esprit scientifique dont ils sont la conséquence. L'auteur fait voir ensuite que cet idéal issu de la science est complet, en ce sens qu'il satisfait pleinement les aspirations les plus profondes et les plus diverses de l'homme. Afin de ne pas allonger inutilement ce compte-rendu, je me borne à signaler ce chapitre du livre, bien qu'il en soit une des parties les plus brillantes et que l'auteur y insiste particulièrement sur la part considérable qui dans l'enseignement des sciences devrait être réservée à leur histoire. Une phrase : « c'est à l'ensemble de l'humanité que la science apporte, avec la liberté, ce sentiment de confiance, de sécurité, qui en est le fruit », m'a fait songer à cette parole admirable de SAMUEL GOMPERS : « Les hommes ne savent pas quelle chose sûre est la liberté». — Qu'on ne nous objecte pas que certains domaines, tout ce qui touche à l'âme par exemple, sont inaccessibles à la science. Ici aussi, la science (histoire des religions, sociologie religieuse, psychologie, biologie) dit son mot (ou vraisemblablement le dira, puisqu'a priori on ne peut lui assigner aucune limite) ; elle intervient par des études dont il n'est plus raisonnable aujourd'hui de contester le principe et les méthodes et où le matérialisme, système métaphysique, n'a rien à voir. — Enfin, dans un dernier chapitre : l'épopée humaine, M. BAYET évoque l'effort de l'homo sapiens en un raccourci dont le lyrisme prenant est une des plus convaincantes démonstrations de la thèse avancée par l'auteur : « la morale qui nous lance, par la liberté et dans l'union, à la recherche illimitée du vrai, n'a rien d'une sagesse pauvre ou bassement calculatrice ».

Ainsi se termine ce livre excellent, si riche, si logique, au style clair, où pour la première fois on trouve explicitement formulée la moralité (esquissée déjà par POINCARÉ dans l'article mentionné plus haut) de cette aventure profondément humaine qu'est l'activité scientifique, moralité

qui nous rappelle à ceux de nos devoirs qui devraient constamment nous apparaître comme les plus urgents, ces devoirs, comme disait si joliment JEAN CASSOU, que la planète semble attendre de nous, devoirs envers notre quotidien le plus minutieux et le plus proche et devoirs envers certains de nos amis plus lointains que les étoiles.

J. PELSENEER.

Francis R. Packard.—*History of Medicine in the United States.* Vol. I, xxv + 656 pp., frtsp. and 66 pl.; Vol. II, xi and pp. 657-1323, and 36 pl. PAUL B. HOEBER, Inc., New York, 1931. $ 12.00.

This pretentious work is by no means a second edition of the volume published by Dr. PACKARD under the same title in 1901. It is an entirely different effort, completely altered as to organization and presentation, and written afresh from the first page. Dr. PACKARD is to be sincerely congratulated on his very successful compilation of widely scattered material and upon bringing it so well together to tell its story. "The author has endeavored to gather all the local information available concerning different parts of our country but has met with absolute failure in many instances. Consequently there is a great unevenness of material in the following pages, and in some cases he realizes that there will be criticism on the ground of omission. He can only hope that such omission will awake some of his critics to attempt to fill the lacunae."

In the introduction Dr. PACKARD reviews briefly the many publications, biographical and otherwise, relating to various phases of his subject, and lists the important source material in a special bibliography at the end of the second volume. Quite justly Dr. PACKARD extols the influence of Mr. HOEBER's long sustained interest in historical publications in medicine. Also with justice is attention called to the extraordinary number and value of the contributions to the subject from Professor WILLIAM SNOW MILLER's Wisconsin Medical History Seminar, by Prof. MILLER, Dr. W. S. MIDDLETON, and Dr. W. J. MEEK.

Dr. PACKARD's work is really an account of English medicine in the English colonies which later developed into the United States. Some idea of the scope of the effort may be obtained by listing the chapter headings: I. Medical Events Connected with the Early History of the English Colonies in America; II. Epidemic Sickness and Mortality in the English Colonies in North America from its Earliest Discovery to the Year 1800; III. Early Medical Legislation; IV. The Earliest Hospitals; V. Medical Education Before the Foundation of Medical Schools; VI. The Earliest Medical Schools; VII. Pre-Revolutionary Medical Publications; VIII. The Medical Profession in the War for Independence; IX. The Medical Department of the Army from the

Close of the Revolution to the Close of the Spanish-American War (a well organized survey by Col. P. M. ASHBURN, U.S.A.); X. History of the Medical Department of the United States Navy (an excellent summary, with special bibliography, by Lieut.-Com. R. P. PARSONS, U.S.N.); XI. Some of the Medical Schools Founded during the First Half of the Nineteenth Century; XII. Outlines of the Development of Medical Practice and Education in Some of the States (compiled from a great number of independent writings); XIII. Foreign Influences on American Medicine; XIV. Some Notable Events in American Medicine and Surgery; XV. The Beginnings of Specialism in America. There are also eleven appendices, of which the last three, on Homeopathic Medical Colleges, Women in Medicine, and Eclectic Schools, respectively, are especially interesting.

The two volumes are lavishly illustrated, and there are liberal quotations from original documents. Particularly well done is the account of epidemic sicknesses in the colonies before 1800, in which the difficulties over yellow fever are thoroughly discussed. The story of the founding of the Pennsylvania Hospital (the oldest in the United States) in 1751, largely through the efforts of Dr. THOMAS BOND (1712-1784) and BENJAMIN FRANKLIN (1706-1790), is re-told at length from T. G. MORTON's *History of the Pennsylvania Hospital*, Phila., 1895. Well described is the founding of the first medical school in the colonies in 1765 by JOHN MORGAN (1735-1789), the Medical Department of the College of Philadelphia, later the University of Pennsylvania (1779). Dr. PACKARD skillfully discusses the significance of foreign influences on American medicine, pointing out the initial debt to Edinburgh and London, the remarkable later effect of the Parisian physicians, and finally, the reaction to the German and Austrian schools. Succinctly but accurately, Dr. PACKARD describes some notable events in American medicine: VALENTINE MOTT's (1785-1865) ligation of the innominate artery (1818); H. G. JAMESON's (1778-1855) resection of the superior maxilla (1821); WILLIAM BEAUMONT's (1785-1853) study of digestion (1833); W. W. GERHARD's (1809-1872) differentiation of typhus and typhoid fevers (1837); the discovery of anesthesia, and the resulting controversy,—C. W. LONG (1815-1878) who first used ether (1842),—HORACE WELLS (1815-1848) who first used nitrous oxide (1844),—and W. T. G. MORTON (1819-1868) who demonstrated ether anesthesia at the Massachusetts General Hospital on Oct. 16, 1846; MORRILL WYMAN's (1812-1903) thoracentesis (1850); ERASTUS B. WOLCOTT's (1804-1880) first nephrectomy (1861); JOHN S. BOBBS' (1809-1870) first cholecystotomy (1867); AMOS TWITCHELL's (1781-1850) first ligation of the common carotid (1807, but not published until 1843); E. L. TRUDEAN's (1848-1915) pioneer climatic treatment

of tuberculosis (1878), and the discovery of the cause of yellow fever (1900) by WALTER REED (1851-1902), J. W. LAZEAR (1866-1900), JAMES CARROLL (1854-), and ARISTIDES AGRAMENTE (1868-1931). EPHRAIM McDOWELL's (1771-1830) pioneer ovariotomy (1809); J. MARION SIMS' (1813-1883) first successful operation for vesicovaginal fistula (1853), and O. W. HOLMES' (1809-1894) discussion of the contagiousness of puerpueral fever (1843) are described also. It is interesting to note the reflection of the practical demands of a young and rapidly growing country in the preponderance of surgical innovations.

Dr. PACKARD's survey of medical history in the United States is likely to remain for a very long time the standard authority on the subject. If the volumes are reprinted, a few typographical errors, referring chiefly to names, should be corrected, and it might be worth while to give the dates of men discussed on their first mention. Some attention should be paid to primitive Amerindian medicine, and to the early French and Spanish medicine in the United States. There is an excellent subject and author index.

C. D. LEAKE.

Eric Stone.—*Medicine Among the American Indians.* Clio Medica Series. xv + 139 pp., 17 illust. PAUL B. HOEBER, Inc., New York, 1932. $ 1.50.

It is amazing that this delightful little volume seems to be the first to appear on the subject. As the author states, "The material on the medical practices of the Indians, while voluminous in the aggregate, is hidden in short fragments under a mountain of other lore." Dr. STONE is to be commended for collecting the material, and particularly for summarizing it so succinctly and clearly. The effort is plainly one of love on Dr. STONE's part, for he has studied much of his subject at first hand in living with various tribes, and his work is embellished with several of his own interesting sketches.

The chapter headings indicate the scope of the book: I. Theory of Medical Practices; Religion and Medicine; II. Medicine-men and Medicine Societies; III. Equipment of the Medicine-men; IV. Morbidity; V. Supernatural Therapeutics; VI. Legitimate Therapeutics of Medical Conditions; VII. Treatment of Surgical, Gynecological and Obstetrical Conditions; VIII. Ceremonial Therapeutics; and IX. Conclusions.

A convenient series of some 15 tables summarizes the various drugs used for different medical purposes. The drugs are identified by common and scientific names, the method of use is noted, and reference is also made to the tribe or locality in which the use originated.

Dr. STONE's presentation emphasizes again what has been discussed

in connection with Professor BREASTED's great translation of the Edwin Smith Surgical Papyrus (Chicago, 1930; G. SARTON, *Isis*, 15, 355-367, 1931), namely, that primitive man coped with illness caused in an obviously understandable manner, as a fracture from a fall, in a direct matter-of-fact way, and that magic was invoked only when the course of the disease was not readily apparent, as in infections. The surgery and obstetrics of the Amerinds was sound, even by present standards. The empirical process of trial and error taught them the value of several important drugs, such as tobacco, lobelia, datura (" Jimson weed "), cascara sagrada, and willow, but their use of drugs was largely conditioned by their demonological theory of disease and therefore required magic as an adjuvant. The ceremonial therapeutic magic of the Amerinds is especially well summarized in the present volume.

Dr. STONE's survey is restricted to the Indians within the territorial limits of the United States. This is unfortunate, since the culture of these stocks seems to have blended by traceable transitions to that of the Mexican, Central American, and South American aborigines. The truly extraordinary collection of material assembled by the late Mr. E. W. PAYNE of Springfield, Ill., and never adequately studied, illustrates this proposition almost conclusively. At any rate, in the writings of FRANCISCO FLORES (*Historia de la Medicina en Mexico*, 1886-1888), and the late lamented Dr. NICOLAS LEON, one may find very valuable information which may be significantly related to what Dr. STONE discusses. Dr. STONE's useful bibliography should also include reference to Prof. A. L. KROEBER's Studies on the California Indians (*Bull. No.* 78, *Smithsonian Inst., Bur. Amer. Ethnol.*, 1925, 684 pp.).

Dr. STONE's conclusions are important : " The practice of medicine among the American Indians should only be evaluated by a comparison with the medical practices of other civilizations at the same stage of development... They were true Stone Age men as late as 1870. But their medical practices were far in advance of the Stone Age, being comparable to that of Chaldeans, Assyrians, Hebrews and early Greeks, and with that of an isolated period in the Middle Ages in Europe. The common basis of all these groups was a demonological theory of disease. Even as compared with their contemporary whites, they were not entirely to be scorned. Their treatment of wounds, fractures, and empyema was equal to or better than that of the white physicians of the 18th century. Their handling of the retained placenta anticipated CREDÉ by a century. They were considerably behind, however, in the understanding of internal medicine and had no knowledge of contagious diseases... The medical practices of the American Indian... were marked by sincerity, confidence and picturesqueness and were in many respects effective." C. D. LEAKE.

E. Jeanselme.—*Histoire de la Syphilis : Son Origine, Son Expansion.* Extraite du *Traité de la Syphilis*, Tome I. G. Doin, Paris, 1931. 432 pp., 58 figs.

This skillfully organized, well written, carefully documented, and attractively illustrated monograph is likely to remain for a long time the standard reference work on the subject. Certainly few scholars will be able to approach it with the authority of Professor Jeanselme, for not only is he one of the world's ablest historians of medicine but he has also had a vast and significant clinical experience with the disease the history of which he so thoroughly discusses.

Having thus praised the effort, I must lament its lack of an index. There is not even a table of contents ; Perhaps this omission will be corrected in a contemplated index-volume to the series which this inaugurates.

A list of the chapter headings here will indicate the scope of the book : it will by no means indicate the wealth of detailed information to be found in it (943 references are quoted, and conveniently, in foot-notes).

The chief theories concerning the American or anti-American origin. Is it possible to uphold an argument for or against the antiquity of syphilis? Is syphilis mentioned in antiquity or the Middle Ages? Is it possible to establish that syphilis existed in the old world before the discovery of America? The expedition of Charles VIII in Italy and the spread of syphilis in Europe at the end of the XVth century. Invasion of syphilis into North Africa, Near and Far East. Surprise of contemporaries at appearance of syphilis in Europe, —scourge of all classes without distinction,—historians, poets, and satirists mentioning.

First Period : End of XVth to middle of XVIth century. The most ancient descriptions of syphilis. Grunpeck, Villalobos, Jean de Vigo, Ulrich v. Hutten, Fracastor, Jean Fernel. Chief characteristics of syphilis at its appearance in Europe : cutaneous manifestations, headache, and osseous pains, etiologic and prophylactic notions, mercury rubs and sweating.

Second Period : Middle of XVIth to end of XVIIIth Century. Boerhaave, Astruc, Nil Rosen a Rosenstein, Raulin, Nemez Ribeiro Sanchez. Discussion on origin of syphilis between Astruc and Sanchez. Iatromechanical theory, chemical theory, parasitic theory. A. Deidier. Etiological notions, accidental epidemics of syphilis. Progress of clinical study. Anatomical research, arterial syphilis and aneurisms of aorta, neuro-syphilis. Lesions caused by mercury poisoning. Latent " Verole," hereditary verole and the social results of founding the Hospital Vaugirard, public and private prophylaxis. Therapy : sudorifics, milder mercurial therapy, theories on the action of mercury (Van Swieten and Sanchez). Treatment by empirics and charlatans. New sources of endemic syphilis appearing at end of XVIIIth and beginning of XIXth century.

Third Period : Modern epoch. Theory of sympathy; inflammatory theory. Denial of syphilitic virus. Gonorrhea not syphilis. Studies of Benjamin Bell, J. Hunter and J. F. Fernandez. Theories regarding unity or duality of soft and indurated chancres. Auzias-Turenne; Ph. Ricord; L. Bassereau Rollet.

The contagiousness of secondary exposure : observations and opinions of W. WALLACE, RICORD, and the Palatinate anonymous writer (JULIUS BETTINGER). Works of RICORD and A. FOURNIER. Anatomical studies : aneurism; specific lesions of nerve centers; the nature of general paralysis and locomotor ataxia. Heriditary syphilis and its treatment : BAUMES-COLLES law; PROFETA's law; studies of ADAM OEWRE, of PARROT, and of E. FOURNIER. Antisyphilitic therapy of the XIXth century : rules for the use of mercury according to RICORD and A. FOURNIER; potassium iodide. Private and social prophylaxis against syphilis in the XIXth century.

Fourth or Contemporaneous Period : Experimental syphilis; ROUX and METCHNIKOFF; NEISSER; FINGER and LANDSTEINER; UHLENHUTH and MULZER; BROWN and L. PEARCE; BERTARELLI; plural treponema theory; C. LEVADITI and A. MARIE. Distribution of treponema in the body; rabbit syphilis. Discovery of the treponema : SCHAUDINN and HOFFMANN; its culture : NOGUCHI; its presence in the spinal cord : NOGUCHI. The serology of syphilis : BORDET and GENGOU, WASSERMANN. The reaction type and its modification. The reaction of floculation. The HERXHEIMER reaction. Reactivation : GENNERICH, MILIAN. Lumbar puncture applied to diagnosis and control of treatment : RAVAUT. Contemporary diagnosis and treatment of syphilis : association of the clinic and laboratory. Syphilitic reinfection : E. PONTOPPIDAN, L. QUEYRAT, and M. PINARD. Contrast between European and indigenous syphilis : E. JEANSELME; LACAPERE; C. LEVADITI and his collaborators. Articular nodes : BERTIN; LUTZ; JEANSELME; DE QUERVAIN. Mechanism of hereditary syphilis : FINGER and LANDSTEINER; PINARD. Lesions of the endocrine glands in hereditary syphilis : V. HUTINEL. The therapeutic revolution with " 606 " : EHRLICH; with bismuth : SAZERAC and LEVADITI; treatment of general paralysis : VON JAUREGG, A. SEZARY and BARHE. Attempts at preventive treatment of syphilis : ROUX and METCHNIKOFF, L. FOURNIER, L. GUENOT and A. SCHWARTZ. Social prophylaxis of syphilis. Summary.

While JEANSELME notes the extraordinary wealth of current work on syphilis, he quite properly condenses its discussion to some fifty pages. The bulk of the volume is thus devoted to a full and judicious consideration of the many interesting historical aspects of the disease.

To the mooted question as to whether or not syphilis was recognized or referred to in ancient or mediaeval times, no definite answer seems possible. As Professor JEANSELME indicates, the many references quoted from ancient authorities in support of the affirmative will not bear critical examination. From the lengthy discussion of whether or not it is possible to show the presence of syphilis in Europe prior to the discovery of America, one gathers that documentary evidence supports the affirmative, although this view is disputed by many. Professor JEANSELME quotes most of the evidence on both sides, and the discussion is well illustrated by facsimiles taken from SUDHOFF. Direct pathological evidence from bones definitely pre-Columbian was recently offered by LORENZ MICHAELIS (*Vergleichende mikroscopische Untersuchungen an rezenten, historischen und fossilen menschlichen Knochen, zugleich ein Beitrag zur*

Geschichte der Syphilis, Jena, 1930, VIII + 92 p.). This study with other recent ones on the same subject are noted by Professor JEANSELME in an addendum. One wonders how they may modify his own views.

One of the valuable features of the monograph is the excellent account of the expedition of CHARLES VIII to Italy, and its consequences in the light of the social and sanitary habits of the period. The earliest descriptions of syphilis, contemporaneous with its explosive and stupefying outbreak at the close of the 15th and the first half of the 16th century are ably reviewed. It is my personal feeling that the significance of FRACASTOR's poem *Syphilis sive Morbus Gallicus* (Verona, 1530), and his further discussion in his *De Contagionibus* (Venice, 1546) of the disease he named, deserve more extended and thorough discussion than afforded by the author. Certainly there should not have been an error in the date given for the poem.

The most important and valuable feature of Professor JEANSELME's book is the comprehensive and detailed account of clinical opinions and other aspects of the disease during the 17th, 18th, and early 19th centuries. Even skilled syphilologists are often unacquainted with the many influential contributions made to the understanding of the disease during this time. In this monograph one may find the matter thoroughly reviewed and admirably presented, with a host of helfpul and stimulating references to the original sources.

In his brief survey of current work on syphilis, Professor JEANSELME is properly conservative, contenting himself chiefly with a short statement, adequately documented, of important observations. It is unfortunate, however, that no reference is made to A. S. LOEVENHART's remarkable studies on the chemotherapy of neurosyphilis, which were climaxed by the introduction of tryparsamide for the treatment of paresis (1924). Similarly, the KAHN precipitation test is important enough to warrant mentioning, as is also VOEGTLIN's theory regarding the action and toxicity of arsenical drugs in syphilis. I would like further to have Professor JEANSELME's ideas on possible evolutionary changes in the virulence of the syphilitic organism and in human resistance to it, particularly as influenced by drugs. But perhaps these current problems, as well as the fascinating one of the mechanism of action of anti-syphilitic drugs, are to be discussed philosophically and historically in other volumes in the series which this monograph opens.

Professor JEANSELME's own summary may best afford an idea of what he considers historically demonstrated and significant with respect to our knowledge of syphilis :

" Attribué tout d'abord à une cause surnaturelle, le mal mystérieux qui terrorisa l'Occident à la fin du XV^{e} siècle ne tarde pas à être rangé parmi les maladies trans-

missibles par la contagion et l'hérédité. Ses symptômes sont décrits; la succession de ses accidents se précise; d'emblée, un agent thérapeutique de grande vertu est découvert, le mercure, qui après une lutte opiniâtre triomphe du gaïac et des autres bois ou racines sudorifiques.

" Les faits qui s'imposent à l'observation sont reliés par des théories qui reflètent, à chaque époque, les concepts généraux admis en médecine. Considérés tout d'abord comme le résultat de la viciation, du déficit ou de la prédominance d'une des quatre humeurs qui constituent l'organisme, les accidents syphilitiques sont plus tard imputés à des causes mécaniques ou chimiques. Lentement s'édifie la notion qui assimile le virus à un ferment capable d'agir à dose infinitésimale, de transformer en sa propre substance les tissus avec lesquels il entre en contact, de se régénérer et de se reproduire indéfiniment comme les infiniment petits.

" Chemin faisant, la structure des lésions syphilitiques visibles à l'œil nu est enregistrée avec une admirable précision par les anatomopathologistes du XV^e^ siècle, et les histologistes, au siècle suivant, indiquent les caractéristiques du processus scléro-gommeux.

" Au XIX^e^ siècle, le bloc vénérien se morcelle. La syphilis est libérée des éléments hétérogènes jusqu'alors confondus avec elle : la blennoragie et le chancre simple. Le rôle que jouent les accidents secondaires, la plaque muqueuse en particulier, dans la propagation de la syphilis d'origine vénérienne ou accidentelle, est mis en évidence par la clinique et l'expérimentation.

" Grâce aux moyens d'investigation dont nous disposons à l'époque contemporaine, le domaine de la syphilis héréditaire ou acquise s'est singulièrement accru depuis quelque trente ans.

" Cependant, il faut reconnaître que bien des lacunes restent encore à combler. La culture du tréponème est pratiquement impossible. La syphilis expérimentale n'a fourni que peu de données nouvelles; elle n'a pas réussi à élucider le mécanisme de la syphilis héréditaire. Les tentatives de vaccination et de sérothérapie ont échoué.

" En revanche, la chimiothérapie s'est enrichie en ces derniers temps d'agents thérapeutiques d'une incomparable puissance : l'arsenic et le bismuth, qui ont pris place à côté du mercure sans le supplanter.

" En recourant à ces moyens d'action, nous avons en vue non seulement de guérir le malade, mais aussi de le rendre incapable de transmettre l'infection dont il est atteint. Ainsi donc, traiter un syphilitique virulent, c'est en même temps stériliser un porte-germe, et partant c'est assurer la prophylaxie sociale. Telle est l'orientation actuelle. Si cette notion est diffusée dans tous les milieux sociaux par une active propagande, si les moyens de traitement sont mis à la portée de tous, il n'est pas douteux que le fléau sera bien près d'être vaincu."

It is to be noted that this admirable summary omits reference to the origin and antiquity of the disease. Professor JEANSELME's great study thus remains consistently and laudably conservative to the end.

C. D. LEAKE.

Thirty-Fifth Critical Bibliography

of the

History and Philosophy of Science and of the History of Civilization

(to August 1932)

This thirty-fifth Bibliography contains about 350 items, some of which have been kindly contributed by the following scholars :

C. W. Adams (Hertford, England)
R. C. Archibald (Providence, R. I.)
H. Bévenot (Weingarten Abbey, Württemberg)
T. L. Davis (Cambridge, Mass.)
L. Guinet (Brussels)
C. A. Kofoid (Berkeley, Cal.)
C. D. Leake (San Francisco)
E. O. v. Lippmann (Halle a. S.)
D. B. Macdonald (Hartford, Conn.)
J. R. Partington (Wembley, England)
J. Pelseneer (Brussels)
E. M. Pickman (Boston)
L. Sapin (Brussels)
J. W. Thompson (Berkeley, Cal.)
L. Thorndike (New York)
J. K. Wright (New York).

This bibliography includes the sixteenth series of addenda and errata to the *Introduction to the History of Science* (Baltimore and London, 1927 and 1931). An index of authors will be found at the end.

Papers and books sent to the Editor are included in this bibliography if they are relevant to its purpose. They may be the object of analytical notes or longer reviews, if this seems sufficiently necessary and the services of competent scholars are available. It is obvious that only a small number of publications can be adequately reviewed and that it is not even possible to give a brief description of each and every one. However, our classification is so comprehensive and so minute, that even if we do nothing but give the accurate title of an item and put it in the proper place, we are already rendering a real service to the author, the publisher, and the learned public. There is no relation between the importance of a publication and the length of the note devoted to it.

The ultimate aims of this undertaking are : (1) to establish the History of Science as an independent discipline ; (2) to demonstrate inductively

the Unity of Knowledge and the Unity of Mankind ; (3) to serve as a center of information and rallying ground to the scholars engaged in our studies.

GEORGE SARTON.
Paris.

ALEXANDER POGO.
Harvard Library, Study 189
Cambridge, Massachusetts
August 23, 1932.

PART I

FUNDAMENTAL CLASSIFICATION (CENTURIAL)

IVth Century B. C. (second half)

Manquat, Maurice. Aristote naturaliste. (*Cahiers de philosophie de la nature*, V) 128 p. Paris, VRIN, 1932. ISIS

Curriculum vitae d'ARISTOTE : ARISTOTE naturaliste; Le professeur en chaire. Le texte de l'Histoire des Animaux : La division de l'Histoire des Animaux. Les régions dont ARISTOTE pouvait connaître la faune. Les sources d'ARISTOTE : Poètes, philosophes, médecins; HERODOTE; Les pêcheurs; Les chasseurs; Les vétérinaires; Les apiculteurs; Les éleveurs, bergers, laboureurs, voyageurs; Les possesseurs d'animaux apprivoisés; Les " On dit ". Les travaux personnels. Les ressources d'ARISTOTE zoologiste. La méthode d'ARISTOTE dans l'Histoire des Animaux. Quelques particularités de l'Histoire des Animaux.

A. P.

IIIrd Century B. C. (second half)

Lenzen, V. F. ARCHIMEDES' theory of the lever. *Isis*, 17, 288-89, 1932. ISIS

Ist Century (whole and first half)

Staehle, Karl. Die Zahlenmystik bei PHILON VON ALEXANDRIA. VI+92 p. Leipzig, TEUBNER, 1931. ISIS

K. STAEHLE s'est proposé, dans cette thèse, présentée à la faculté de philosophie de Tubingen, de donner, par la publication des textes des commentateurs, une idée aussi exacte que possible du περὶ ἀριθμῶν de PHILON D'ALEXANDRIE et de rechercher jusqu'à quel point les constatations qu'on y trouve sur les propriétés des nombres sont en relation avec le judaïsme (près de 20 p. sont consacrées au nombre sept). L. G.

Ist Century (second half)

Foakes-Jackson, Frederick John. The acts of the apostles. XX+ 236 p. London, HODDER and STOUGHTON, 1931. ISIS

Nero (*Introduction*, 1, 247; 2, 1024). Der sogenannte Smaragd bei PLINIUS ist ein grünes Glas, das NERO für seine schwachen Augen gebraucht; „smaragdinus" ist in vielen Fällen einfach = grün.
E. O. v. L. ISIS

Weigall, Arthur. NÉRON. Traduction par MAURICE GUÉRIN. 343 p., 8 grav., Paris, PAYOT, 1931 (30 fr.). ISIS

Le but de l'auteur est de faire revivre NÉRON tel que ses contemporains le voyaient. Le nom de NÉRON ramène devant l'esprit la vision d'un monstre inhumain que la légende chrétienne considéra comme la Bête de l'Apocalypse. L'historien se trouve devant le problème de savoir comment un homme tenu pour un monstre a pu être tant aimé par le peuple de Rome.

« Il n'est guère possible de supposer que NÉRON nous serait parvenu à ce jour sous les traits du personnage le plus monstrueux de l'histoire romaine si la Chrétienté à ses débuts ne l'avait identifié avec l'Antéchrist. Il est plus vraisemblable qu'on l'eût simplement considéré comme le plus mauvais des empereurs ou comme un de ceux dont l'ineptie fut criminelle ».
L. S.

Zeitlin, Solomon. JOSEPHUS on JESUS. With particular reference to the Slavonic JOSEPHUS and the Hebrew JOSIPPON. V+118 p. Philadelphia, Dropsie College for Hebrew and Cognate Learning, 1931. ISIS

VIIth Century (whole and first half)

Sengupta, P. C. BRAHMAGUPTA on interpolation. *Bull. Calcutta Math. Soc.*, 23, 125-28, 1931. ISIS

VIIth Century (second half)

Greek fire (*Introduction*, 1, 494). It would seem that the Greek fire was thrown by means of hand grenades made of earthenware of which many examples have been found in Ba'albek and Ḥamā. I have seen in Ḥamā (April 1932) some of the Ḥamā grenades in the museum of the Danish expedition led by Dr. H. INGHOLT. The Ba'albek examples have been discussed by FRIEDRICH SARRE: Keramik und andere Kleinfunde der islamischen Zeit von Baalbek, p. 21-24, 1925. Handbrandgeschosse aus Ton. S. A. aus dem 3. Bde der Ergebnisse der Ausgrabungen und Untersuchungen in den Jahren 1898 bis 1905. G. S. ISIS

XIIth Century (whole and first half)

Bartholomew of Salerno (*Introduction*, 2, 239). PFEIFFER's Arzneibücher (*Introduction*, 2, 1092) sind keine Originale sondern meist Auszüge aus BARTHOLOMAEUS VON SALERNO. E. O. v. L. ISIS

Chu I-chung (*Introduction*, 2, 220). CHU I-CHUNG's Buch über Destillation von 1120 (!) ist offenbar untergeschoben. E. O. v. L. ISIS

Cistercian rule (*Introduction*, 2, 155 ; also p. 55). The agricultural progress due to the Cistercians was not only due to better economic organization. For example, see J. W. THOMPSON : *Feudal Germany* p. 569 : " The Cistercians studied plant life for food purposes, seed germination, grafting of fruit trees, and mayhap even cross-fertilization. In 1237, the Cistercian house at Doberan had a glass-roofed house for the purpose of experimentation." See FRANZ WINTER : *Die Cistercienser des nordöstlichen Deutschlands* (2 vols., Gotha, 1868-71 ; vol. 2, 171). J. W. T. ISIS

Distillation. The discovery of distillation is not Arabic, Chinese, or European (*Introduction*, 2, 145), since it was certainly in use in Alexandria by the earliest chemists during the first three centuries (HOEFER : *Histoire de la chimie*, I, 255, 1842 ; BERTHELOT : *Origines de l'alchimie*, 162, 1885 ; BORRICHIUS : *Hermetis Aegyptiorum chemicorum sapientia*, 156, Hafniae, 1674). J. R. P. ISIS

Ekkehard of Aura (*Introduction*, 2, 258). Vom Kloster Aura bestehen noch sehr sehenswerthe Ruinen, die man von Kissingen aus oft besichtigt. E. O. v. L. ISIS

al-Ḥarīrī (*Introduction*, 2, 270). Die Makamen übersetzte in vollendetester Weise FR. RÜCKERT ; eines der grössten Sprachkunststücke. E. O. v. L. ISIS

al-Khāzinī (*Introduction*, 2, 216). H. BAUERREISS : Zur Geschichte des spezifischen Gewichtes im Altertum und Mittelalter. (Diss. Erlangen, 1914). E. O. v. L. ISIS

Robert of Chester (*Introduction*, 2, 176). MORIENI de transfiguratione metallorum... ist nach dem Titel der De compositione alchemie (Paris, 1564) mit dieser identisch. E. O. v. L. ISIS

XIIth Century (second half)

Alcoholic distillation (*Introduction*, 2, 408). Über Entdeckung von Alkohol und Mineralsäuren s. meine Beiträge (1923), besonders auch VITALIS DE FURNO. E. O. v. L. ISIS

Hildegard (*Introduction*, 2, 387). HILDEGARD soll anfangs kein Latein verstanden haben, in ihrem Alter etwas. E. O. v. L. ISIS

(Ibn Rushd). Averroës. Tahāfot at-tahāfot. Texte arabe établi par MAURICE BOUYGES, S. J. XL+680 p. (*Bibliotheca arabica scholasticorum*, Série arabe, Tome III) Beyrouth, Imprimerie catholique, 1930 (prix broché 105 fr.). ISIS

Critical edition of the Tahāfut al-tahāfut based not only upon the three fundamental mss. of Constantinople, but also upon the Hebrew and Latin versions. It splendidly completes the edition of AL-GHAZZĀLĪ's Tahāfut al-falāsifa prepared by the same scholar and issued by the same presses in 1927 (*Isis*, 10, 497). This is the first scientific edition of one of the most important philosophical texts of the Middle Ages. It has been prepared with extreme care, and the typography is excellent. Latin running titles at the top of each page are a great convenience. The text is followed by abundant indices, glossaries, and lists of the main arguments. Our best wishes to the learned editor for the preparation of vol. 1 of the same magnificent collection to be devoted to the Maqāṣid al-falāsifa of AL-GHAZZĀLĪ. G. S.

Joachim de Flore. L'évangile éternel. Première traduction française, précédée d'une biographie par EMMANUEL AEGERTER. I. La vie de JOACHIM DE FLORE. II. L'évangile éternel. 2 vol. (*Textes du Christianisme*, III et IV). Paris, RIEDER, 1928. ISIS

Scalinci, Noè. BENVENUTO GRASSO (o GRAFFEO) e l'oftalmiatria della scuola salernitana. *Riv. di sc. med. e natur.*, 22, 399-416, 1931. ISIS

L'examen de l'*Ars probata oculorum* de BENVENUTO GRASSO, le range parmi les salernitains, et non parmi les arabistes, comme on le fait habituellement. Examen de l'ophtalmiatrie de l'école de Salerne. L. G.

Webb, Clement C. J. JOHN OF SALISBURY. X+186 p. London, METHUEN, 1932. ISIS

XIIIth Century (whole and first half)

'Arabī, Ibn (*Introduction*, 2, 596-98). Don MIGUEL ASÍN's recent

book : *El Islam cristianizado* (541 p., 2 pl., Madrid, 1931) is largely devoted to the discussion of IBN 'ARABI's views (*Isis*, 17, 271-73).
G. S. ISIS

(Ch'ang-Ch'un). The travels of an alchemist : the journey of the Taoist CH'ANG-CH'UN. Translated by ARTHUR WALEY. XII+166 p. London, ROUTLEDGE, 1931. ISIS

Reviewed by H. A. R. GIBB in *Geographical Journal*, 78, 311, 1931. " CH'ANG-CH'UN's travels are far less important than those of his Buddhist predecessor, HSÜAN-TSANG. Mr. WALEY has gone direct to the original sources and utilized the works of both Chinese and Japanese commentators. It was early in 1220 that CH'ANG-CH'UN set out from his home in Shantung at the summons of CHINGIZ-KHAN, whom he met at length in Afghanistan in May 1222, and he returned thence to Peking, which he reached in the spring of 1224. There is much of both cultural and geographical value contained in his laconic phrases." C. W. A.

Ch'iu Ch'ang-ch'un (*Introduction*, 2, 645). WALEY's Titel ist irreführend, CH'ANG-CH'UN ist nur Taoist und spricht kein Wort von Alchemie. E. O. v. L. ISIS

(Compass) (*Introduction*, 2, 630, also 671). VITRIACUS sagt nur dass der Stein zum Reiben der eisernen Nadel aus Indien stammt.
E. O. v. L. ISIS

Ferguson, John. A short biography and bibliography of MICHAEL SCOTUS. p. 72-100, Glasgow, Printed for the Glasgow Bibliographical Society by JACKSON, WYLIE & Co., 1931. ISIS

I regret that this valuable Scotian bibliography reached me too late to be mentioned in vol. 2 of my *Introduction*. It was carefully prepared for the press by Miss ELIZABETH H. ALEXANDER of Glasgow often mentioned in *Isis*. Another FERGUSON memoir edited by her, on POLYDORE VERGIL, was recently published in *Isis* (XVII, 71-93). Miss ALEXANDER has been cataloguing and rearranging all the FERGUSON MSS., and I understand that there are still 77 unpublished papers, some of which we hope to publish in *Isis* gradually. G S.

Jordanus Nemorarius (*Introduction*, 2, 614 ; also 213, 504). Buchstaben zur Verallgemeinerung von Grössen gebraucht schon ARISTOTELES. E. O. v. L. ISIS

Kantorowicz, Ernst. FREDERICK THE SECOND, 1194-1250. English version by E. O. LORIMER. XXVII+724 p., 7 maps. London, CONSTABLE, 1931. ISIS

Scuder, Vida Dutton. The Franciscan adventure. A study in the

first hundred years of the Order of St. Francis of Assisi. XVI+432 p. London, DENT, 1931. ISIS

Uṣaibi'a, Ibn abī (*Introduction*, 2, 685). Über die oft von Ihnen citierte Ausgabe des IBN ABĪ UṢAIBI'A von AUGUST MÜLLER (bes. S. 685) möchte ich Ihnen, da ich der Schwager des so früh Verstorbenen bin (seine Schwester ist meine Frau), Folgendes mitteilen : Nach vieljährigen Vorarbeiten wurde das Buch, der erhofften Billigkeit wegen, in Aegypten gedruckt, u. der befreundete deutsche Orientalist Dr. SPITTA der wegen Tuberkulose dort weilte, führte die Aufsicht. Als dieser aber gegen Ende des Druckes kränker würde (er starb alsbald) u. die Verbindung nach Europa infolge der Beschiessung Alexandrias durch die Engländer unterbrochen war, benützte dies der Drucker, um seine Arbeit willkürlich abzuschliessen, den Index nach Belieben abzukürzen, u.s.w. ; als mein Schwager das so entstellte Buch in die Hand bekam, blieb ihm nichts übrig, als es auf eigene Kosten, in richtiger Weise ergänzt, nochmals herauszugeben, u. daraus erklären sich die von Ihnen angeführten Umstände. Er hat diese, meines Erinnerns, auch in der Vorrede erwähnt, ich habe sie aber nicht zur Hand, u. kann daher jetzt nicht nachsehen.

E. O. v. L. ISIS

XIIIth Century (second half)

Alfonso X el Sabio (*Introduction*, 2, 834-42). To the translations should be added that of the *Picatrix*, which is said by the Latin Ms. to have been translated from Arabic into Spanish in 1256 by ALFONSO's order. See L. THORNDIKE's *Magic and experimental science* (vol. 2, 813, 822-23) and SARTON's *Introduction* (vol. 1, 668). The date of that translation is 1256, not 1252. L. T. ISIS

Bodewig, E. Die Stellung des heiligen THOMAS VON AQUINO zur Mathematik. *Arch. Gesch. Philos.*, 11, 1-34, 1931. ISIS

Faraj ben Salīm (*Introduction*, 2, 833). Long list of Latin Mss. of the *De medicinis expertis* in THORNDIKE's *Magic and experimental science* (vol. 2, 771-74). That treatise was printed in the 1481 edition of RASIS. For further discussion, see THORNDIKE (vol. 2, 752-58, 771-74). ISIS

Geber (*Introduction*, 2, 1043). The " critical " work of DARMSTAEDTER mentioned on p. 1045 is not very accurate and the bibliographical part, in particular, contains errors. The same applies to the work

of LIPPMANN which is also quoted and whose statements are not infrequently the exact opposite of those of the authorities he quotes. The bibliographical information on p. 1044 contains some errors which I corrected some years ago in a published note. J. R. P.
ISIS

Marc the Greek. (*Introduction*, 2, 1039). The statement that " one Latin Ms. at least bore a Greek title, *περὶ τῶν πυρῶν*, is, apparently, taken from LIPPMANN (mentioned under Criticism), who took it from KOPP, who took it from GMELIN, who refers to JEBB's edition of BACON's *Opus majus* as saying that a Ms. with this (Greek) title was in the collection of Dr. MEAD. JEBB (op. cit. *praefatio*, fol. C *recto*) actually says : " Marco quodam Graeco in tractatu, quem vocat Librum ignium," and DUTENS (Histoire des découvertes attribuées aux modernes, 3 ed., 4 to., p. 197, London, 1796) says : " Le Docteur JEBB, Editeur de ROGER BACON, m'a communiqué la copie qu'il avoit tirée lui-même du manuscrit du Docteur MEAD. Le titre du manuscrit en question porte ceci : *Incipit Liber Ignium a Marco Graeco perscriptus cuius virtus et efficacia est ad comburendem hostes tam in mari quam in terra.*" It is thus the same as the Paris Ms. and has not a Greek title. The latter seems to have been supplied by the Teutonic thoroughness of GMELIN, and is now well " established " through a chain of copyists : no doubt it will be still further quoted from the *Introduction*. I published a note on this some years ago. J. R. P. ISIS

Rubruquis (*Introduction*, 2, 1053). Dass des Kaspische Meer ein Binnensee sei sagt richtig schon HERODOT. E. O. v. L. ISIS

Sa'dī (*Introduction*, 2, 872). Ausgezeichnete Übersetzungen : Rosengarten von NESSELMANN (Berlin, 1864), Aphorismen und Sinngedichte von BACKER (Strassburg, 1879), Divan von FR. RÜCKERT (Leipzig, 1892). E. O. v. L. ISIS

Thomas Aquinas (*Introduction*, 2, 918). Summa. Übersetzung und Commentar, SCHNEIDER, 10 Bde. (Regensburg, 1885 ff.). E. O. v. L.
ISIS

XIVth Century (whole and first half)

Campbell, Anna Montgomery. The Black Death and men of learning. XII+210 p. (History of Science Society Publications, 1). New York, Columbia University Press, 1931. ISIS

Dallari, Umberto. Due documenti inediti riguardanti LIUZZO e MONDINO DE' LUZZI. *Riv. di storia d. sc. med. e natur.*, 23, 1-6, 1932. ISIS

Publication de deux documents, peu importants d'ailleurs, remontant aux premières années du XIV^e^ siècle; cet article est suivi de la liste des œuvres de MONDINO et des MSS. que l'on en possède encore. L. G.

Gessler, Jean. Le livre des Mestiers de Bruges et ses dérivés. Quatre anciens manuels de conversation publiés par JEAN GESSLER, avec le concours des Maîtres imprimeurs de Bruges et de la Fondation universitaire de Belgique. 6 fasc. réunis en 1 farde. Bruges, Consortium des Maîtres imprimeurs, 1931. ISIS

Un des plus anciens, si pas le premier, manuels de conversation, ou *livres benoits*, destinés à l'enseignement pratique d'une langue étrangère, en l'occurence du français, fut composé vers 1349 par un maître d'école brugeois. Ce manuel appelé par son auteur anonyme *Le Livre des Mestiers*, à cause du rôle prépondérant qu'y jouent les métiers de Bruges et leurs représentants, exerça une influence considérable, qui se fit sentir de la Tamise jusqu'au Rhin, puisqu'il fut imité aussi bien en Allemagne qu'en Angleterre. On conserve en effet à Cologne le Ms. unique d'un *Gesprächbüchlein* du XV^e^ siècle, dont la composition remonte aux années 1360-1377; en Angleterre trois exemplaires des *Dialogues in French and English*, imprimés vers 1483 par WILLIAM CAXTON, le *prototypographus* anglais; enfin ,à Paris, à la Bibliothèque Mazarine, un exemplaire unique du *Vocabulaer* imprimé avant 1501 par l'Anversois ROLAND VANDEN DORDE.

Ce sont ces quatre textes bilingues, collationnés par JEAN GESSLER, que vient d'éditer, en une publication très belle, d'une forme typographique parfaite, le Consortium des Maîtres imprimeurs de Bruges, dont l'âme semble bien être E. VERBEKE, le directeur de l'imprimerie Sainte-Catherine, 'imprimeur d'*Isis*.

Le *Livre des Mestiers* (Ms. du fond néerlandais à la Bibliothèque Nationale) a été publié en 1875 par H. MICHELANT. Du *Gesprächbüchlein* (Archives de Cologne), H. VON FALLERSLEBEN a donné une édition particulièrement correcte en 1854. Les *Dialogues in French and English* ont été publiés en 1900 par H. BRADLEY. Le *Vocabulaer* ne semble pas avoir été réimprimé avant l'édition actuelle.

Tous les textes ont été collationnés, confrontés par J. GESSLER, et les erreurs de transcriptions nombreuses des précédentes éditions sont signalées dans l'introduction française (fasc. I) et sa traduction flamande (fasc. II). Le fasc. III donne le *Livre des Mestiers;* le N° IV le *Gesprächbüchlein;* le N° V, le texte publié par W. CAXTON; enfin le dernier fasc. reproduit le vocabulaire « romain et flameng » d'Anvers. L. G.

XIVth Century (second half)

Rickert, Edith. Are there more CHAUCER manuscripts? *Times Literary Supplement*, p. 1028, London, Dec. 17, 1931. ISIS

Rickert, Edith. CHAUCER at St. Paul's School? *Time Literary Supplement*, p. 76, London, Feb. 4, 1932. ISIS

XVth Century (whole and first half)

Birkenmajer, Alexander. Zur Lebensgeschichte und wissenschaftlichen Tätigkeit von GIOVANNI FONTANA (1395?-1455?). *Isis*, 17, 34-53, 1932. ISIS

Schub, Pincus. A mathematical text by MORDECAI COMTINO (Constantinople, XV century). *Isis*, 17, 54-70, 1932. ISIS

XVth Century (second half)

Leonardo da Vinci

Marcolongo, Roberto. La meccanica di LEONARDO DA VINCI. Memoria estratta dal Vol. XIX, Serie 2a, N. 2 degli *Atti della R. Accademia delle Scienze fisiche e matematiche di Napoli*. II+148 p., 116 figs. Napoli, S.I.E.M., 1932. ISIS

In 1929 appeared MARCOLONGO's important memoir, *Le ricerche geometrico-meccaniche di Leonardo da Vinci* (cf. *Isis* 15, 226); « serenamente e senza inopportune esagerazioni », MARCOLONGO gave us a clear survey of LEONARDO's mathematical knowledge. The present memoir—a continuation, in a way, of the memoir of 1929—is the most up-to-date and comprehensive survey of LEONARDO's knowledge of and contributions to mechanics. « Una preparazione... sempre serena e coscienziosa » is apparent troughout the memoir. When DUHEM wrote on LEONARDO, the publication of the Codice Atlantico was not completed; FRITZ SCHUSTER, in his *Zur Mechanik Leonardo da Vincis* (Diss. Erlangen, 1915), makes no use of the London codices; IVOR B. HART, in *The mechanical investigations of Leonardo da Vinci*, London, 1925, could not make use of *I fogli mancanti al codice di Leonardo da Vinci su 'l volo degli uccelli*, published in 1926. MARCOLONGO's memoir is based on all the known writings of LEONARDO—including the codices Arundel 263 and Forster 1—and, of course, on the work of his predecessors as well as on his original studies. The first part of the memoir, Statics, begins with an important chapter on mediaeval statics and the sources of LEONARDO; the second part, Dynamics, begins with a chapter on Greek and mediaeval dynamics. The illustrations are reproductions of LEONARDO's drawings; the numerous quotations were collated with the MSS. There is no index. A. P.

XVIth Century (whole and first half)

B. — *Physical Sciences*

Dobbin, Leonard. PARACELSUS and the discovery of hydrogen (letter

to the editor). *Journal of Chemical Education*, 9, 1122-24, 1932.

ISIS

The passage of PARACELSUS' *Archidoxa*, which has been cited by HOEFER, KOPP, and others as evidence that PARACELSUS recognized that an inflammable gas is given off when sulfuric acid acts on iron mentions neither iron nor acid; it concerns the separation of the Aristotelian elements, and does not indicate that PARACELSUS suspected hydrogen or anything like it.

T. L. D.

D. — *Medical Sciences*

Rudy, Hirsch. AMATUS LUSITANUS. *Archeion*, 13, 424-39, 1931.

ISIS

AMATUS LUSITANUS, 1511-1568, médecin et botaniste.

E. — *Alia*

Ferguson, John. Notes on the work of POLYDORE VERGIL " De inventoribus rerum." Preface by ELIZABETH H. ALEXANDER. *Isis*, 17, 71-93, 1 pl., 1932. ISIS

Grenard, Fernand. Baber. First of the Moguls. Translated and adapted by HOMER WHITE and RICHARD GLAENZER. 253 p. London, Butterworth, 1930. ISIS

Tanfani, Gustavo. Gli attributi somato-psichici del carattere anormale secondo CARDANO. *Riv. di storia d. sc. med. e natur.*, 22, 433-40, 1931. ISIS

XVIth Century (second half)

C. — *Natural Sciences*

Taylor, E. G. R. A sixteenth-century Ms. navigating manual in the Society's library. London, *Geographical Journal*, 78, 346-52, 1931.

" By the early sixteenth century it had become usual for the Theory of the Sphere and the Tables and Rules for fixing position to be bound up together as the Navigating Manual proper, while the shipmaster or pilot provided himself with the particular Pilot Book or Rutter, and the particular Chart which he needed. The Italian manuscript entitled ' Brieve conpendio de larte del navegar', in the Society's Library, contains three out of the four parts of the complete Manual, namely, the section on the Sphere, the Rules and Tables, and the Chart; only the Rutter is absent, and certain supplementary notes and tables are inserted instead. The provenance of the Manual is quite clear from the Dedicatory Preface : it was written by an Italian pilot, BATTISTA TESTA ROSSA, and is dated 1557, when BATTISTA

had settled in London." A number of important points in the history of navigation are dealt with in this analysis of the Manual. C. W. A.

Tusser, Thomas. Five hundred points of good husbandry. Introduction by Sir WALTER SCOTT, and a benediction by RUDYARD KIPLING, incorporated in a foreword by E. V. LUCAS. XII+336 p. London, Tregaskis, 1931. ISIS

XVIIth Century (whole and first half)

A. — *Mathematics*

Bosmans, H. (S.J.). THÉODORE MORETUS de la compagnie de Jésus, mathématicien (1602-1667). De Gulden Passer. Le Compas d'Or, 6, 57-162, 1928. ISIS

Gennaro, Silvio di. « Essay pour les coniques » di B. PASCAL. *Periodico di matematiche*, 104-12, 1932. ISIS

Traduction, avec notes, de l'*Essay pour les coniques*, dont un facsimile a paru ici (*Isis*, 10, 16-20, 1928).

Mitrovitch, Radicha. La théorie des sciences chez DESCARTES, d'après sa géométrie. 64 p. Paris, CROVILLE-MORAND, 1932. ISIS

Tropfke, Johannes. Das *x* als Symbol der unbekannten bei DESCARTES und seinen Nachfolgern. *Archeion*, 13, 300-19, 1931. ISIS

DESCARTES n'employait pas toujours *x* comme symbole de l'inconnue, mais il semble cependant avoir eu pour ce signe une préférence plus marquée que pour *y* et *z*. Après lui, l'emploi de *x* devient de plus en plus fréquent. L. G.

B. — *Physical Sciences and Technology*

Adams, C. W. A note on GALILEO's determination of the height of lunar mountains. *Isis*, 17, 427-29, 1932. ISIS

Gough, J. W. The superlative prodigall. A life of THOMAS BUSHELL. VIII+172 p. Bristol, ARROWSMITH, 1932. ISIS

Rosenfeld, L. MARCUS MARCIS Untersuchungen über das Prisma und ihr Verhältnis zu NEWTONS Farbentheorie. *Isis*, 17, 325-30, 1932. ISIS

Rougier, Louis. L'affaire PASCAL. *Mercure de France*, 513-53, Nov., 1931. ISIS

LOUIS ROUGIER rouvre le procès intenté en 1906 par FÉLIX MATHIEU à PASCAL (la lettre de PASCAL à PÉRIER, datée du 15 novembre, 1647, et où il décrit l'expérience du « vide dans le vide » serait apocryphe). L'affaire était considérée comme close, après les réponses de LÉON BRUNSCHVICG surtout. ROUGIER accuse ce dernier d'avoir falsifié les textes pour les besoins de la défense de PASCAL. L. S.

C. — *Natural Sciences*

Pelseneer, Jean. GILBERT, BACON, GALILÉE, KÉPLER, HARVEY et DESCARTES : leurs relations. *Isis*, 17, 171-208, 1932. ISIS

D. — *Medical Sciences*

Bontius, Jacobus). Bontius Tropische Geneeskunde. Bontius On Tropical Medicine. LXXIV+459 p., 4 facsim., 108 pl. ***Opuscula selecta Neerlandicorum de arte medica***, fasciculus X. Amsterdam, Nederlandsch Tijdschrift voor Geneeskunde, 1931. ISIS

Ce volume, publié à l'occasion du soixante-quinzième anniversaire de *Nederlandsch Tijdschrift voor Geneeskunde*, qui publie les *Opuscula selecta Neerlandicorum de Arte medica*, dont *Isis* rend compte chaque année, renferme une introduction (en néerlandais et en anglais)laquelle est une bonne étude générale de la vie et de l'œuvre de JACOB BONTE (1592-1631), et le texte original latin, accompagné de sa traduction anglaise, de son œuvre écrite; les planches originales sont reproduites. — I. Animadversions on book I and II of GARTIA AB ORTA; II. Dialogues on the preservation of health; III. An account of the diseases, natural history and medicine of the East Indies; IV. Some select observations taken from the dissection of dead bodies; V. On quadrupeds, birds and fishes; VI. On plants and spices.—Le vol. se termine par de courtes notes biographiques sur les auteurs cités par J. BONTE et par une liste des animaux et des plantes par lui mentionnés. L. G.

E. — *Alia*

Husserl, Edmund G. Méditations cartésiennes ; introduction à la phénoménologie. Trad. de l'allemand par GABRIELLE PEIFFER et EMANUEL LEVINES. 136 p. Paris, COLIN, 1931. ISIS

Développement de deux conférences faites à Paris en 1929, à la Société française de philosophie. HUSSERL y définit ainsi (p. 134) sa position philosophique : « La science positive est une science de l'être qui s'est perdu dans le monde. Il faut d'abord perdre le monde par l'ἐποχή, pour le retrouver ensuite dans une prise de conscience universelle de soi-même. Noli foras ire, dit SAINT AUGUSTIN, in te redi, in interiore homine habitat veritas ». L. G.

Leroy, Olivier. A French bibliography of Sir THOMAS BROWNE. 97 p. London, HARRAP, 1931. ISIS

Pickman, Edward Motley. The collapse of the scholastic hierarchy in seventeenth-century France. 34 p. *Proceedings of the Massachusetts Historical Society*, 64, 1931. ISIS

Rome, A. L'origine de la prétendue mélodie de PINDARE. *Les Etudes Classiques*, 1, 11 p., 1932. ISIS

Apropos of ATHANASIUS KIRCHER (1601-1680) and of his *Musurgia universalis, sive ars magna consoni et dissoni*, etc., Rome, 1650.

XVIIth Century (second half)

A. — *Mathematics*

Bosmans, H. (S.J.) Le Jésuite mathématicien anversois ANDRÉ TACQUET (1612-1660). De Gulden Passer. Le Compas d'Or, 3, 63-87, 1925. ISIS

Villamil, Richard de. NEWTON : the man. Foreword by ALBERT EINSTEIN. VI+111 p. London, Knox, 1931. ISIS

B. — *Physical Sciences and Technology*

Crommelin, C. A. Das isochrone konische Pendel von CHRISTIAAN HUYGENS. *Physica*, 11, 359-64, 1931. ISIS

Nierenstein, M. HELVETIUS, SPINOZA, and transmutation. *Isis*, 17, 408-11, 1932. ISIS

Whitaker-Wilson, Cecil. Sir CHRISTOPHER WREN. His life and times. XX+268 p. London, METHUEN, 1932. ISIS

C. — *Natural Sciences*

Dampier, William. Voyages and discoveries. With an introduction and notes by CLENNELL WILKINSON. XXXVI+312 p. London, Argonaut, 1931. ISIS

Reviewed by A. JOSE in *Geographical Journal*, 78, 391-92, 1931. " The editor is candid; he describes it as " a chance collection of snippets, of left-overs from the " New Voyage Round the World," not even arranged in chronological order; a third of it narrates DAMPIER's travels in Tonquin, Malacca, and northern Sumatra in 1688-89; another third reverts to his first voyage to Campeachy, 1673-78; and the rest is given up to what is perhaps the most strictly useful work he ever did : his Discourse of Trade-winds, etc., parts of which are still embodied in Admiralty handbooks. This section is separately edited by Lieutenant-Commander A. COLQUHOUN BELL."

C. W. A.

(De Graaff, Nicolaus). Reisen van NICOLAUS DE GRAAFF, 1639-1687. Edited by J. C. M. WARNSINCK. XLII+230 p. (Vol. 33 of the *Linschoten Vereeniging*'s publications). The Hague, NIJHOFF, 1930. ISIS

Reviewed by C. R. BOXER, *Geographical Journal*, 78, 172-73, 1931. "In the course of fifty years of practically ceaseless travelling he visited the East Indies five times, South America and Greenland once, and the Levant twice. Mention must be made of DE GRAAFF's adventurous climb up Table Mountain in 1678. On this occasion he calculated the height as the equivalent of 1123 metres. VALENTIJN, who, as the editor points out, had countless times utilized DE GRAAFF's work without acknowledgement in his celebrated 'Old and New East India,' gives the correct (sic) height as the equivalent of 6996 metres, and sneers at DE GRAAFF's estimate in a most unclerical manner. Since the real height is 1092 metres, it will be seen that DE GRAAFF's estimate was, for the time, a wonderfully accurate calculation."

C. W. A.

D. — *Medical Sciences*

Dorveaux, Paul. Apothicaires membres de l'Académie Royale des Sciences, VI. NICOLAS LÉMERY. *R. d'hist. de la pharmacie*, 208-19, port., 1931. ISIS

Faucci, Ugo. Contributo alla storia della scabbia. *Riv. di storia d. sc. med. e natur.*, 22, 153-69, 198-214, 257-370, 441-75, 1931. ISIS

C'est en 1687, à Livourne, que GIOV. COSIMO BONOMO (16...-1696) et GIACINTO CESTONI (1673-1718), tous deux élèves de FRANCESCO REDI, ont reconnu que la gale est exclusivement due à l'acare. Un siècle plus tard (1786) JOHANN ERNST WICHMANN (1740-1802) rappelait et confirmait l'œuvre de ses prédécesseurs. Enfin, en 1834, SIMON FRANÇOIS RENUCCI retrouvait, de son côté, l'acare et assurait le triomphe définitif de la nature parasitaire de la gale. Cet article est accompagné du facsimile de la lettre manuscrite de BONOMO à REDI. L. G.

E. — *Alia*

Madan, Falconer. Oxford books. A bibliography of printed works relating to the University and city of Oxford or printed or published there; with appendices, annals, and illustrations. Vol. 3, Oxford literature, 1651-1680. XLVII+621 p. Oxford, Clarendon Press, 1931. ISIS

Morison, Stanley. ICHABOD DAWKS and his news-letter. With an account of the DAWKS family of booksellers and stationers, 1635-1731. VIII+44 p., facs. New York, MACMILLAN, 1931. ISIS

XVIIIth Century (whole and first half)

A. — *Mathematics*

Arrighi, Gino. Un problema geometrico in « De gnomone meridiano bononiensi » di E. MANFREDI (Una lettera inedita di P. GUIDO GRANDI). *Archeion*, 13, 320-24, 1931. ISIS

L'auteur publie une lettre inédite de GUIDO GRANDI (1671-1746) à TOMMASO NARDUCCI (1680-1739). L. G.

Hellman, C. Doris. JOHN BIRD (1709-1776) mathematical instrument-maker in the Strand. *Isis*, 17, 125-53, 2 pl., 1932. ISIS

Neville, E. H. The curve of pursuit. London, *Mathematical Gazette*, 15, 436, 1931. ISIS

Bibliographical references to the literature in England from 1737 onwards. C. W. A.

B. — *Physical Sciences and Technology*

Brunet, Pierre. L'introduction des théories de NEWTON en France au XVIII[e] siècle (avant 1738). VII+355 p. Paris, BLANCHARD, 1931. ISIS

Reviewed by HÉLÈNE METZGER, *Isis*, 17, 433-35, 1932.

Lippmann, Edmund O. von. Anfänge der Zuckersiederei in Stettin. *Die deutsche Zuckerindustrie*, p. 467, 1932. ISIS

Pelseneer, Jean. Le dernier autographe de NEWTON. *Isis*, 17, 331, 1932. ISIS

Sarton, George. Discovery of the main nutation of the earth's axis. With facsimile reproduction (no. XV) of JAMES BRADLEY's account of it (*Philosophical Transactions*, no. 485 beginning vol. 45, p. 1-43, 1748). *Isis*, 17, 333-83, facsim., 1932. ISIS

C. — *Natural Sciences*

White, Gilbert. Journals of GILBERT WHITE. Edited by WALTER JOHNSON. XLVIII+463 p. London, ROUTLEDGE, 1931. ISIS

Reviewed in *Natural History Magazine* (British Museum of Natural History), 3, 111-12, 1931. " In January, 1768, GILBERT WHITE received from DAINES BARRINGTON a copy of his newly-published ' Naturalist's

Journal,' and at once began to fill it up day by day, entering in the appropriate columns readings of barometer and thermometer, rainfall, notes on the first appearances of flowers and birds, and the like. The annual volumes were regularly filled in until a few days before WHITE's death in 1793. A great deal of the matter in these notes was used in writing his 'Natural History of Selborne,' published in 1788. The manuscript of the Journal has been in the library of the British Museum since 1881. In this volume, Mr. JOHNSON has attempted to select and print in their original form and sequence all those passages, not already used by WHITE in his 'Natural History,' which have scientific worth, or which shed light on the social life of the old naturalist." C. W. A.

D. — *Medical Sciences*

Heischkel, Edith. Die Medizinhistoriographie im XVIII. Jahrhundert. *Janus*, 35, 67-105, 125-51, 1931. ISIS

Vallée, Arthur. Cinq lettres inédites de JEAN FRANÇOIS GAULTIER à M. DE RÉAUMUR de l'Académie des Sciences. *Mémoires de la Société Royale du Canada*, Section I, 24, 31-43, 1930. ISIS

Reviewed by RENÉ CHARPENTIER, *Bulletin de la Soc. française d'histoire de la médecine*, 25, 487-88, 1931.

E. — *Alia*

Weulersse, G. Les physiocrates. XVI+322 p., Paris, GASTON DOIN, 1931. ISIS

L'histoire des physiocrates est celle des commencements de l'économie politique moderne. L'auteur ne conduit pas l'histoire de ces novateurs au delà de 1770, date à laquelle leur système a atteint son plein épanouissement, sans rien perdre encore de sa pureté.

Le système physiocratique est basé sur la production exclusive de l'agriculture. Tous les éléments d'un système existaient dans la littérature économique anglaise contemporaine; cependant c'est en France que le premier système s'est formé et QUESNAY a précédé de vingt ans ADAM SMITH. Les physiocrates sont les dignes contemporains de l'Encyclopédie, de ROUSSEAU et de BUFFON. Ils ont commencé l'éducation économique du peuple français. Avec eux le problème de l'origine des richesses s'est trouvé transporté du domaine de la circulation dans celui de la production. Ils ont aussi dégagé le rôle décisif du facteur capital qu'ils conçoivent sous forme d'avances appliquées au perfectionnement de la technique, à l'élargissement du cadre des entreprises, le tout obtenu par l'augmentation du rendement et la diminution des frais. Leur conception trop strictement juridico-économique de la société les a empêchés de comprendre la gravité du problème de gouvernement qui se posait à la France. « S'ils n'ont pas été les maîtres en politique, leur gloire est assez grande d'avoir assuré la fondation d'une science nouvelle dont la politique ne pourra méconnaître les lois : l'économie politique ».

L. S.

XVIIIth Century (second half)

C. — *Natural Sciences*

Baldino, Maria. FRANCESCO CETTI, illustratore della fauna sarda. *Riv. di storia d. sc. med. e natur.*, 22, 476-79, 1931. ISIS

FRANCESCO CETTI (1726-1778). Étude des vertébrés de la Sardaigne. L. G.

Roule, Louis. BERNARDIN DE ST-PIERRE et l'harmonie de la nature. 252 p. Paris, FLAMMARION, 1930. ISIS

Santos, Virginia. GOETHE e a anatomia. *Arquivo de Anatomia e Antropologia*, 14, 781-94, 1931. ISIS

D. — *Medical sciences*

Drewitt, F. Dawtrey. The note-book of EDWARD JENNER in the possession of the Royal College of physicians of London. With an introduction on JENNER's work as a naturalist. VIII+49 p., port. Oxford, University Press, 1931. ISIS

Reviewed by CHARLES A. KOFOID, *Isis*, 17, 435-36, 1932.

E. — *Alia*

Helderman, Leonard C. GEORGE WASHINGTON, patron of learning. XVI+187 p., 12 pl. New York, Century, 1932 ($ 2.50). ISIS

Interest in science in educational institutions at the end of the 18th century was stimulated by THOMAS JEFFERSON in the College of William and Mary, and by BENJAMIN FRANKLIN in the College of Philadelphia. BENJAMIN RUST dreamed of a graduate school, but it is not generally known to what degree and in what ways President GEORGE WASHINGTON was interested in the new learning. This interest took the form of a project for a National University which he recommended in his first and last messages to Congress. The project seems to have had its origin while WASHINGTON was quartered at Harvard College in 1775. He selected a site in the nation's capital city and left a part of his patrimony to endow a national university. In his statement of the aims of university education he specifically mentions the " promotion of science and literature " and urges the importance of agriculture, chemistry, and mathematics. Financial disasters dissipated the legacy, and opposition of entrenched educational interests have conspired to date to defeat the realization of WASHINGTON's dream. The development of the scientific departments of the United States Government, and the privately founded Carnegie Institution in a measure fulfil this dream of the Father of his Country. C. A. K.

Honeywell, Roy John. The educational work of THOMAS JEFFERSON. XVI+295 p. Cambridge, Harvard University Press, 1931. ISIS

XIXth Century (whole and first half)

B. — *Physical Sciences and Technology*

Cramp, William. MICHAEL FARADAY : and some of his contemporaries. IX+68 p. London, PITMAN, 1931. ISIS

(Faraday). Faraday and marine boilers. *Nature*, 128, 1031, 1931. ISIS

Hadfield, Sir Robert Abbott. FARADAY and his metallurgical researches : with special reference to their bearing on the development of alloy steels. XX+329 p., 58 pl. London, CHAPMAN and HALL, 1931. ISIS

Sarton, George. Discovery of conical refraction by WILLIAM ROWAN HAMILTON and HUMPHREY LLOYD (1833). With facsimile reproduction (no. XIV) of HUMPHREY LLOYD's first paper On the Phaenomena presented by Light in its Passage along the Axes of Biaxal Crystals, originally published in The *London and Edinburgh Philosophical Magazine and Journal of Science*, conducted by Sir DAVID BREWSTER, RICHARD TAYLOR and RICHARD PHILLIPS (vol. 2, 112-20, 1833). *Isis*, 17, 154-70, 1 pl., facs., 1932. ISIS

White, A. M. ; Friedman, H. B. On the discovery of palladium. *Journal of Chemical Education*, 9, 236-45, 1932. ISIS

The anonymous announcement of the properties of palladium by WOLLASTON in 1803, and the anonymous offering of samples of the metal for sale without any indication of its source, led to results which WOLLASTON could certainly not have foreseen, to acrimonious debate, and to the ultimate scientific disgrace of RICHARD CHENEVIX (1774-1830) who thought that he had synthesized palladium from platinum and mercury. T. L. D.

C. — *Natural Sciences*

Chaine, J. La grande époque de l'anatomie comparative. *Scientia*, 50, 365-74, 1931. ISIS

Examen comparé de l' « École de CUVIER », l' « École de GEOFFROY ST. HILAIRE », et l'« École des Philosophes de la Nature ». L. G.

Studnička, F. K. Aus der Vorgeschichte der Zellentheorie. H. MILNE

EDWARDS, H. DUTROCHET, F. RASPAIL, J. E. PURKINJE. *Anat. Anzeiger*, 73, 390-416, 1932. ISIS

D. — *Medical Sciences*

Pincherle, Bruno. Uno scritto di GIUSEPPE MAZZINI sulla scoperta della circolazione del sangue. *Riv. di storia d. sc. med. e natur.*, 22, 417-32, 1931. ISIS

A propos d'un article donné en avril 1838 à la *London and Westminster Review* par GIUSEPPE MAZZINI (1805-1872) pendant son exil en Angleterre. L. G.

E. — *Alia*

Dorveaux, Paul. MITOUART et l'Académie royale des sciences ; MITOUART inaugure les cours du Collège de France. *Rev. d'Hist. de la Pharmacie*, 254-62, 1931. ISIS

Cet article se réfère au pharmacien LOUIS ALEXANDRE JACQUES MITOUART (1766-1848), fils de PIERRE FRANÇOIS MITOUART (1733-1786), également pharmacien, connu pour avoir conservé le cerveau de VOLTAIRE (actuellement au musée de la Comédie Française). L. G.

Pommier, Jean. L'évolution de VICTOR COUSIN. *R. d'hist. de la philosophie*, 5, 172-203, 1931. ISIS

XIXth Century (second half)

B. — *Physical Sciences and Technology*

Bernhard, Hermann. ALEXANDER BORODIN : chemist and musician *Journal of Chemical Education*, 9, 153-54, 1932. ISIS

Portrait and brief letter to the editor. T. L. D.

Cesari, Carlo. Un italiano precursore di F. SIEMENS. *Archeion*, 13, 336-37, 1931. ISIS

Ce précurseur est ENRICO ROSSI, de Turin, qui imagina un dispositif de « four à travailler le fer, chauffé par la flamme perdue de deux autres fours ». Malheureusement, l'auteur oublie de donner la date de cette invention, qu'il cite d'après le « Guide du chauffeur » de GROUVELLE et TAUNER (1858). L. G.

Lodge, Sir Oliver. Advancing science : being personal reminiscences of the British Association in the nineteenth century. 191 p. London, BENN, 1931. ISIS

Reviewed by R. T. G., *Nature*, 128, 982-84, 1931.

Lodge, Sir Oliver. Past years : an autobiography. 364 p., 13 pl. London, HODDER and STOUGHTON, 1931. ISIS

Picard, Emile. La vie et l'œuvre de GABRIEL LIPPMANN. *Revue scientifique*, 70, 129-41, 1932. ISIS

Lecture faite à la séance publique annuelle du 14 décembre 1931.

Schuyler, Hamilton. The ROEBLINGS. A century of engineers bridge-builders, and industrialists. The story of three generations of an illustrious family, 1831-1931. XX+425 p. Princeton, University Press, 1931. ISIS

Struve, Otto. THEODORE ALEXANDROVICH BREDIKHIN. Memoirs of the Russian Scientific Institute in Belgrad. No. 6, pp. 35-54. Belgrad, 1932. (In Russian). ISIS

A good biographical sketch of TH. A. BREDIKHIN (1831-1904), the astronomer. A bibliography of 205 papers by BREDIKHIN is added; of these, 164 were in French, 19 in Russian, 17 in German, and 5 in Italian.

A. P.

C. — *Natural Sciences*

Iltis, Hugo. Life of MENDEL, pioneer in heredity. Transl. from the German by EDEN and CEDAR PAUL. 336 p., 12 pls., 10 figs. New York, NORTON, 1932 ($ 5.00). ISIS

This is a translation of the original German edition " GREGOR JOHANN MENDEL, Leben, Werk und Wirkung ", Berlin, 1924. C. A. K.

(Maudslay, Alfred Percival). ALFRED PERCIVAL MAUDSLAY. *Geographical Journal*, 78, 1-12, 1931. ISIS

(Norwood, Surrey, 18.3.1850; Morney Cross, Hereford, 22.1.1931). Honorary professor of archaeology, National Museum of Mexico. " Between the ages of thirty-one and forty-four MAUDSLAY devoted his life to the Maya ruins, spending the whole or a large part of eight dry seasons in the field."

C. A. W.

Zeiss, Heinz. ELIAS METSCHNIKOW, Leben und Werk. Uebersetzt und bearbeitet nach der von Frau OLGA METSCHNIKOWA geschriebenen Biographie, dem Quellenmaterial des Moskauer Metschnikow-Museums und eigenen Nachforschungen. 196 p. Jena, FISCHER, 1932 (M. 10). ISIS

This life of the eminent Russian zoologist, bacteriologist, and biologist is based upon the earlier biography, Vie d'ELIE METSCHNIKOW (1845-1916), by OLGA METSCHNIKOW (1921), (*Isis*, 4, 519-21) but adds to it a considerable volume of additional source material and certain introductory generalizations.

The latter are to be found in critical estimates of the influence and characteristics of METSCHNIKOFF's childhood, youth, and early manhood; of his life in Russia and his work as a zoologist, especially of his basic contributions to the extension of the germ layer theory to the invertebrates; and to his later life and work in France and his contributions to phagocytosis and his philosophical ideas of senescence, death, and sex. The additions of source material are unfortunately left by the biographer largely in the form of detached footnotes and remarks on Mrs. METSCHNIKOFF's life of her husband, instead of being wrought into relationship to a critical new biography of this great scholar. This material consists of a bibliography of biographical notices, lists of scientific honors, of photographs, and of source material in the recently established "Metschnikoff Museum" in Moscow. In addition to these there is a bibliography which brings the number of citations from 123 in the French edition of METSCHNIKOFF's contributions to science up to 241 titles, largely from Russian sources. The footnotes and comments are very extensive, forming about half of the book. They include extracts from correspondence, letters from colleagues, corrections in fact of errors in earlier biographies, comments on METSCHNIKOFF's relations with his contemporaries and colleagues, and bibliographic and biographical data of basic documentary value. C. A. K.

D. — *Medical Sciences*

Compton, Piers. The genius of LOUIS PASTEUR. IX+361 p. London, OUSELEY, 1932. ISIS

Pusey, William Allen. A doctor of the 1870's and 80's. XIII+153 p., 26 illus. Springfield, Ill., THOMAS, 1932. ISIS

The simple story of R. B. PUSEY (1836-1889), father of the author. It gives an excellent picture of rural American medical practice in the period indicated. C. D. L.

E. — *Alia*

Abb, Gustav. Aus fünfzig Jahren deutscher Wissenschaft. Die Entwicklung ihrer Fachgebiete in Einzeldarstellungen. Edited by GUSTAV ABB. Berlin, DE GRYUTER, 1930. ISIS

(Ewald). Briefe an EWALD. Aus seinem Nachlass. Herausgegeben von R. FICK und G. VON SELLE. V+223 p., Göttingen, in Komission bei VANDENHOECK & RUPRECHT, 1932 (12 R.M.) ISIS

GEORG HEINRICH AUGUST EWALD (1803-1875). Le but des éditeurs n'est pas de donner une biographie du savant orientaliste et théologien, mais un aperçu de l'histoire de la philologie orientale.

Lettres de BOLLENSEN (1809-1896), BOPP (1791-1867), BURNOUF (1801-1852), GABELENTZ (1807-1874), GILDENMEISTER (1812-1890), J. GRIMM (1785-1863), HAUG (1827-1876), LAGARDE (1827-1891), LASSEN (1800-1876),

MAX MÜLLER (1823-1900), NEUMANN (1793-1870), TH. NÖLDEKE (1836-1930), ROTH (1821-1895). L. S.

Renaud, H. P. J. L'enseignement des sciences exactes et l'édition d'ouvrages scientifiques au Maroc avant l'occupation européenne. *Archeion*, 13, 325-36, 1931. ISIS

Examen de l'état plus que précaire dans lequel se trouvait l'enseignement des sciences exactes au Maroc vers la fin du XIX^e^ siècle; l'auteur cite les ouvrages servant à cet enseignement. Le premier essai de lithographie à Fez ne remonte pas au delà de 1860; les premières imprimeries parurent vers 1875. L. G.

XXth Century

A. — *Mathematics*

Archibald, Raymond Clare. FLORIAN CAJORI (1859-1930). *Isis*, 17, 384-407, 1 pl., 1932. ISIS

Buhl, A. PAUL APPELL. *L'enseignement mathématique*, 30, 5-21, portr., 1931. ISIS

Piaggio, H. T. H. Three Sadleirian professors : A. R. FORSYTH, E. W. HOBSON and C. H. HARDY. London, *Mathematical Gazette*, 15, 461-65, 1931. ISIS

Brief summaries of the work of ANDREW RUSSELL FORSYTH (1858-), Sadleirian professor of pure mathematics in the University of Cambridge (Eng.) 1895-1910, ERNEST WILLIAM HOBSON (1856-), Sadleirian professor 1910-1931, and GODFREY HAROLD HARDY (1877-), Sadleirian professor from 1931. C. W. A.

Schreiber, Edwin W. FLORIAN CAJORI—a tribute. *School Science and Mathematics*, 32, 129-34, port., 1932. ISIS

B. — *Physical Sciences and Technology*

Allen, E. T. Pen portrait of WILLIAM FRANCIS HILLEBRAND, 1853-1925. *Journal of Chemical Education*, 9, 73-83, 1932. ISIS

Biography with portrait. T. L. D.

Armstrong, Eva. The EDGAR FAHS SMITH Memorial Collection, University of Pennsylvania. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 652-54, 1932. ISIS

Browne, Charles Albert. The history of chemical education in America between the years 1820 and 1870. *Journal of Chemical*

Education (Edgar Fahs Smith Memorial Number), 696-728, 1932. ISIS

Dains, Frank B. Advances in the teaching of chemistry since 1914. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 745-50, 1932. ISIS

Forbes, George Shannon. Investigations of atomic weights by THEODORE WILLIAM RICHARDS. *Journal of Chemical Education*, 9, 453-58, 1932. ISIS

Gordon, Neil E. A tribute to EDGAR FAHS SMITH. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 607-11, 1932. ISIS

Hale, Harrison. The history of chemical education in the United States from 1870 to 1914. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 729-44, 1932. ISIS

Hale, Harrison. Sidelights on the life of EDGAR FAHS SMITH. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 620-34, 1932. ISIS

Kendall, James. ALEXANDER SMITH as an educator. *Journal of Chemical Education*, 9, 254-60, 1932. ISIS

Sympathetic characterization with portrait. T. L. D.

McKee, Ralph H. ALEXANDER SMITH, the investigator. *Journal of Chemical Education*, 9, 246-53, 1932. ISIS

Brief account of SMITH's scientific work with portrait and bibliography. T. L. D.

Newell, Lyman C. Chemical education in America from the earliest days to 1820. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 677-95, 1932. ISIS

Newell, Lyman C. Historical sketch of the division of history of chemistry, American Chemical Society. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 667-69, 1932. ISIS

Parsons, Charles L. PRIESTLEY memorial and medal. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 643-51, 1932. ISIS

Smith, Edgar Fahs. A chapter in historical chemistry. *Journal of*

Chemical Education (Edgar Fahs Smith Memorial Number), 635-42, 1932. ISIS

(Smith, Edgar Fahs). Publications of EDGAR FAHS SMITH, scientific papers, brochures on the history of chemistry, books on the history of chemistry, theses carried out under the direction of EDGAR FAHS SMITH, biographical accounts of EDGAR FAHS SMITH appearing since 1928. *Journal of Chemical Education*, 655-65, 1932. ISIS

Taggart, Walter T. EDGAR FAHS SMITH. *Journal of Chemical Education* (Edgar Fahs Smith Memorial Number), 612-19, 1932. ISIS

Van Hecke, A. MAURICE ALLIAUME (1882-1931). *Revue des questions scientifiques*, 21, 192-220, 1932. ISIS

Wenstrom, W. H. Historical review of the ultra-short-wave progress. *Proceedings of the Institute of Radio Engineers*, 20, 95-112, 1932. ISIS

C. — *Natural Sciences*

(British Museum of Natural History). Jubilee quinquagenary celebration. London, *Natural History Magazine* (British Museum of Natural History), 3, 134-38, 1931. ISIS

The fiftieth anniversary of the opening of the Natural History Museum building at South Kensington to the public on April 18, 1881. A group photograph of ninety-eight of the delegates is reproduced. C. W. A.

Deffontaines, Pierre. JEAN BRUNHES. *Bulletin Soc. géogr. Lille*, 72, 194-202, 1930. ISIS

JEAN BAPTISTE BRUNHES, 1869-1930.

Driesch, Hans. EUGENIO RIGNANO's Lehre vom Organischen in ihrer Entwicklung. *Scientia*, 51, 71-78, 1932. ISIS

Kaisin, F. L'œuvre scientifique de PIERRE TERMIER (1859-1930). *Rev. des questions scientifiques*, 101, 5-32, 1932. ISIS

PIERRE TERMIER (1859-1930), professeur de géologie générale à l'École des Mines (Paris), est connu surtout par ses travaux sur la géologie des Alpes. L. G.

Paul, J. Harland. The last cruise of the Carnegie. Foreword by JOHN A. FLEMING. XVII+331 p., frontispiece. Baltimore, WILLIAMS & WILKINS, 1932. ISIS

D. — *Medical Sciences*

Gunn, J. A. WALTER ERNEST DIXON (1871-1931). *Journ. Pharmacol. Exper. Therap.*, 44, 1-21, 1932. ISIS

Bio-bibliography, with portrait, of the late Cambridge pharmacologist, whose chief contributions were on the physiology of the lungs, the cerebrospinal fluid, drug addiction, the secretion of the pituitary, and the mechanism of drug action. C. D. L.

Leake, Chauncey D. ARTHUR S. LOEVENHART (1878-1929). *Journ. Pharmacol. Exper. Therap.*, 36, 493-505, 1929. ISIS

Bio-bibliography, with portrait, of the late professor of pharmacology at the University of Wisconsin. His chief contributions were the demonstration with J. H. KASTLE of the reversibility of enzyme action; a theory of lipogenesis in connection with fat metabolism; exhaustive and important studies on biological oxidations and on the chemotherapy of neurosyphilis and other mental diseases. LOEVENHART exerted a notable influence in the promotion of co-operative research, particularly among chemists, pharmacologists and clinicians in the effort to develop better methods for the treatment of the sick. Another account of his work (by H. S. GASSER) appeared in *Science*, 70, 317, 1929. C. D. L.

E. — *Alia*

(Berr, Henri). Hommage à HENRI BERR en commémoration du 30e anniversaire de la *Revue de synthèse historique*, 1900-1930. 26 p. (Paris, 1932). ISIS

Addresses by MAURICE CROISET, ABEL REY, LUCIEN FEBVRE, and HENRI BERR. The front and back covers of the pamphlet are decorated with reproductions of the obverse and the reverse of the medal presented to HENRI BERR on Dec. 16, 1931. A. P.

Clemen, Carl. Mgr. SÖDERBLOM, historien des religions. Traduit par JACQUES MARTY. *Revue de l'Histoire des Religions*, 104, 437-47, 1931. ISIS

Archbishop NATHAN SÖDERBLOM, d. 1931.

PART II

HISTORICAL CLASSIFICATION

Including only the items which could not be included in Part I—the fundamental (centurial) classification. Hence a student of Muslim science, for example, should not peruse simply the notes collected below under the heading "Islam," he should examine as well those included above under the headings VIIth century, VIIIth century, etc.

I. ANTIQUITY

1. — ANTIQUITY (*generalities*)

Pottier, Edmond. L'art Hittite. Second fascicule. 80 p., 51 fig. Paris, GEUTHNER, 1931. (37.50 frcs.) ISIS

Pour le premier fascicule (1926), voir *Isis*, 10, 215. Le second fascicule est consacré à la Céramique de l'Asie Occidentale; ses trois chapitres ont paru d'abord dans le *Journal des Savants* de 1930; « de très légères modifications y ont été apportées pour les faire rentrer dans l'exposé général du problème hittite ". I. La Cappadoce (d'après HENRI DE GENOUILLAC, Céramique Cappadocienne, Musée du Louvre. 2 vol., pl., Paris, GEUTHNER, 1926). II. L'Asie et l'Europe (d'après H. FRANKFORT, Studies in early pottery of the Near East, II (Asia, Europe, and the Aegean and their earliest interrelations). Royal Anthropological Institute. Occasional papers, n° 8, London, 1927). III. Les Indo-Européens et le rôle des Hittites (d'après VIKTOR CHRISTIAN, Untersuchungen zur Paläoethnologie des Orients. V. Das erste Auftreten der Indogermanen in Vorderasien, Mitteilungen der anthopologischen Gesellschaft in Wien, 58, 210-229, 1928).

2. — EGYPT

Heuten, G. La diffusion des cultes égyptiens en Occident. *Revue de l'Histoire des Religions*, 104, 409-16, 1931. ISIS

Lippmann, Edmund O. von. Chemisches aus dem medizinischen " Papyrus Edwin Smith." *Chemiker-Zeitung*, 55, 933, 1931. ISIS

Peet, Thomas Eric. Mathematics in ancient Egypt. *Bulletin of the John Rylands Library*, 15, 35 p., 1931. ISIS

The author concludes : " The Egyptians devised a workable and practical system of notation, performed with ease simple and even complicated arithmetical operations, explored with success the field of simple geometry in two and three dimensions, and devised methods of dealing with most of the mathematical problems of everyday life. That they did not reach the conception of scientific mathematics and its dependence on cogent *a priori* demonstration is merely another instance of the vast debt which the world owes to the Greeks."

Pogo, A. Calendars on coffin lids from Asyut (second half of the third millennium). *Isis*, 17, 6-24, 6 pl., 1932. ISIS

3. — BABYLONIA AND ASSYRIA

Bologa, Valeriu L. Von der Babylonischen Labartu über Arab. Karina zum Krankheitsbegriff Sama in der Rumänischen Volksmedizin. *Janus*, 35e a., 1-16, 1931. ISIS

Les noms des démons de la fièvre donnent la symptomatologie classique de la malaria. Après trois mille ans, dans un cercle de 1.500 km., la vieille légende de Labartu-Marduk s'est conservée. Ses modifications permettent toujours de reconnaître les éléments primitifs.

Pour les historiens de la médecine, il est intéressant de suivre le cycle de ces légendes qui montrent comment, en partant d'une croyance populaire, s'est développée la connaissance des caractères propres d'une maladie.

L. S.

Jean, Charles F. La religion sumérienne d'après les documents sumériens antérieurs à la dynastie d'Isin (-2186). XVI+255 p., 32 pl., map. Paris, GEUTHNER, 1931 (100 frcs.). ISIS

« En général, les historiens de la religion assyro-babylonienne distinguent peu, ou même ne distinguent pas du tout, entre les idées religieuses des Sumériens et celles des Sémites ou Akkadiens. De plus, on admet communément qu'il est impossible de constater aucune évolution dans ces idées. La présente étude est un essai qui a pour but d'exposer la religion sumérienne uniquement d'après les témoignages sumériens. Et parce que les Sémites-Akkadiens qui s'emparèrent du pouvoir, au XXVIIe siècle av. J.-C., purent, au cours de deux siècles de règne environ, exercer leur influence sur les idées et les sentiments religieux de Sumer, nous avons soin, à travers tout l'ouvrage, de grouper sous ces deux chefs : *époque proto-sumérienne*, *époque néo-sumérienne*, les données fournies par nos sources. » « A partir de 2186 avant notre ère, les Sémites redevinrent les maîtres et fondèrent deux dynasties contemporaines et rivales, l'une à Isin, l'autre à Larsa. Cette période est exclue de notre exposé. »

Neugebauer, O. Über die Approximation irrationaler Quadratwurzeln in der babylonischen Mathematik. *Arch. Orientforschg.*, 7, 90-99, 1931. ISIS

4. — GREECE

Evans, Sir Arthur. The earlier religion of Greece in the light of Cretan discoveries. 42 p. (Frazer lecture for 1931, in the University of Cambridge). London, MACMILLAN, 1931. ISIS

Lidell, Henry George ; Scott, Robert. A Greek-English Lexicon. A new edition revised and augmented throughout by HENRY STUART JONES, with the assistance of RODERICK MCKENZIE, and with the

co-operation of many scholars. Part 6 : λ — οἶ, p. 1021-1200 plus 2 unnumbered leaves. Oxford, Clarendon Press, 1932. (Oxford University Press, 114 Fifth Avenue, New York, $ 3.50). ISIS

Part 1 of this Lexicon was reviewed by Dr. SARTON in *Isis*, 8, 200-02; for parts 2 to 5, see his notes in *Isis*, 9, 549; 11, 218; 13, 489; and 16, 519. The dates of publication of parts 1 to 6 are : 1925, 1926, 1927, 1929, 1930, and 1932. The unpublished two-fifths of the Lexicon will appear, in four parts of about two hundred pages each, within the next five or six years, provided that the speed of publication remains the same as for parts 3 to 6. There are six partial lists of addenda and corrigenda, on unnumbered leaves preceding each of the six published parts; these six lists are complementary, not cumulative; those who use the incomplete Lexicon will appreciate cumulative lists of addenda and corrigenda attached to each of the four remaining parts. A. P.

Nilsson, M. P. Moderne mythologische Forschung. *Scientia*, 51, 289-98, 1932 ; traduct. française, ibid., supplément, 144-52. ISIS

Ridgeway, Sir William. The early age of Greece. Vol. II. Edited by A. S. F. GOW and D. S. ROBERTSON. XXVIII+747 p. Cambridge, University Press, 1931. ISIS

Stawell, Florence Melian. A clue to Cretan scripts. VIII+120 p. London, BELL, 1931. ISIS

5. — ROME

Homo, Léon. Les empereurs romains et le christianisme. 232 p., Paris, PAYOT, 1931 (24 fr.). ISIS

L'auteur a étudié la place que la question chrétienne a occupée dans la politique des empereurs païens. L'empereur romain voit, à la fois, dans les chrétiens des ennemis de la patrie puisqu'ils prêchent une religion mondiale, et des ennemis de son propre pouvoir puisque l'empereur est considéré comme un Dieu sur terre. Le christianisme, véritable danger pour les empereurs, était considéré comme un délit parcequ'il contrevenait à deux lois formelles de l'État : la loi sur les religions non autorisées et celle sur les associations illicites. Les deux modalités essentielles de la pensée impériale seront une politique défensive, la persécution et une politique offensive et constructive dont la rénovation du paganisme traditionnel, l'essai de syncrétisme religieux et le monothéisme solaire représentent les étapes successives. Ces deux réalisations aboutissent à un échec complet et annoncent la fin du paganisme et le triomphe de l'idée chrétienne. L. S.

Mirone, Giuseppe. L'acquedotto romano di Augusta Praetoria. *Riv. di storia d. sc. med. e natur.*, 23, 7-24, 1932. ISIS

Schudt, Ludwig. Le guide di Roma : Materialien zu einer Geschichte

der römischen Topographie, unter Benützung des handschriftlichen Nachlasses von OSKAR POLLAK ; hrsg. von LUDWIG SCHUDT. London, FILSER, 1930.

II. MIDDLE AGES

6. — MIDDLE AGES (*generalities*)

Alphandéry, P. La glossolalie dans le prophétisme médiéval latin. *Revue de l'Histoire des Religions*, 104, 417-36, 1931. ISIS

Cheikho, Louis. Catalogue des manuscrits des auteurs arabes chrétiens depuis l'Islam. Tiré de la revue *al-Machriq*, avec appendice et deux tables. 290 p. Beyrouth, Imprimerie Catholique, 1924 (en Arabe). ISIS

Catalogue très précieux que je regrette de n'avoir pas connu plus tôt car je l'aurais utilisé avec profit pour le vol. 2 de mon *Introduction*. J'en ferai usage pour les volumes suivants. Cette riche collection de MSS. dont un grand nombre ne sont pas cités par BROCKELMANN, constitue un instrument de travail de premier ordre dont le maniement est facilité par deux bonnes tables, l'une alphabétique, l'autre dans laquelle les auteurs sont classés d'après leur origine, leur rite, ou leur ordre respectif. G. S.

Dold, P. Alban. Donaueschinger Fragmente eines mehrere Bücher umfassenden medizinischen Rezeptars (in Unzialschrift des 7./8. Jahrhunderts). Leipzig, 1931. ISIS

This 40-page reprint from *Sudhoffs Archiv für Geschichte der Medizin*, H. 2, 1931, affords a good example of scientific rescue work of the relics of antiquity. From a number of unsorted MS. fragments in the Fürstenberg library at Donaueschingen, two double pages were through Father DOLD's care and insight found to belong together, being p. 2, 3, and 6, 7 of a quaternion of a collection of Latin recipes in uncial characters. Being director of the Palimpsest Institute of Beuron Archabbey (Hohenzollern), Father DOLD was able to render the fragments much more legible through his ultra-violet fluorescent apparatus, and prints here the text in full (with one page facsimile). The extant recipes (numbered 36-60 and 77-90) are directly connected with the pharmacological works of GALEN,—partly from the Topographica and partly from the Systematica,—with some free inversions of order. Dr. LUDWIG ENGLERT (who treats the texts medico-historically in part II) finds but two which he cannot trace to GALEN. There seems to be no direct use of CASSIUS FELIX here, but CLM 29136 is a CASSIUS-FELIX fragment, and speculation is rife as to the manuscript back of these fragments that show such early Latin use of medical treatises. H. B.

Koht, Halvdan. The old Norse sagas. 191 p. London, ALLEN and UNWIN, 1931. ISIS

Larsen, Henning. An old Icelandic medical miscellany. 328 p. Oslo, *Det Norske Videnskaps-Akademi*, 1931. ISIS

Reviewed by MARY CATHERINE WELBORN, *Isis*, 17, 436-38, 1932.

Lefebvre des Noëttes, Ct. La « nuit » du moyen âge et son inventaire. *Mercure de France*, 235, 572-99, 1932. ISIS

« Voici dans ce qu'il a d'essentiel l'inventaire technique du moyen âge : IX^e^ siècle : Le harnachement moderne de selle, avec la selle, les étriers, le mors de bride et la ferrure à clous. X^e^ siècle : Le système moderne d'attelage des animaux, avec le collier d'épaules, les traits, le dispositif en file. XII^e^ siècle : Le moulin à eau. Le moulin à vent. La scierie mécanique. La forge à martinet. Le soufflet à plaques et soupapes. La croisée d'ogives. Le vitrail et la vitre. La cheminée domestique. La chandelle et le cierge. Le pavage des routes. La brouette. XIII^e^ siècle : Les lunettes. La charrue à roues et versoir. Le gouvernail d'étambot. XIV^e^ siècle : L'écluse à sas. La poudre à canon. L'horloge à poids. Le rabot. XV^e^ siècle : La polyphonie vocale. L'imprimerie ».

Pirenne, Henri ; Renaudet, Augustin ; Perroy, Edouard ; Handelsman, Marcel ; Halphen, Louis. La fin du Moyen Age. T. I. La désagrégation du monde médiéval (1285-1453) 564 p. ; T. II. L'annonce des temps nouveaux (1453-1492), 322 p. *Peuples et civilisations*, vol. VII, Paris, ALCAN, 1931. ISIS

De ce volume VII de *Peuples et civilisations*, nous extrayons ce qui intéresse plus directement les historiens de la culture humaine. Le siècle qui précède le Grand Schisme compte parmi les plus actifs de l'histoire de l'esprit humain. La philosophie critique de GUILLAUME D'OCCAM (1300?-1348?) apparaît, exigeante en fait de certitude; elle n'aboutit qu'à une nouvelle et stérile sophistique.

Les savants abandonnent la tradition aristotélicienne et fondent sur la raison et l'expérience la physique moderne. Les efforts de ces initiateurs ne sont pas poursuivis. Nul progrès ne sera plus lent que celui d'une étude objective et scientifique du monde; et sauf quelques isolés, NICOLAS DE CUSA (1401-1464), NICOLAS PEROTTI (1430-1480), LÉONARD DE VINCI, nul ne mesurait encore exactement la puissance de la science positive.

PÉTRARQUE inaugure une seconde renaissance de style classique, mais d'inspiration romantique. Après lui, les humanistes subissent l'influence de la raison grecque; philologues et historiens connaissent maintenant avec plus d'exactitude la pensée antique et l'esprit des institutions grecques et romaines. Cependant, la révolution intellectuelle et morale que l'humanisme contient en germe tarde à s'annoncer.

La décadence politique du Saint-Siège, la diminution de son autorité sur les Églises déterminent une sensible désaffection à l'égard de Rome, mais même la rénovation de la vie intellectuelle par l'humanisme ne peut faire prévoir en Europe une révolution religieuse.

Les auteurs concluent que pendant la seconde moitié du XV^e^ siècle, l'esprit se renouvelle et que déjà vivent les germes d'une profonde restauration de la pensée religieuse, de la philosophie, de la science positive et de l'art.

L. S.

Powicke, Frederick Maurice. The medieval books of Merton College. XII+287 p. Oxford, Clarendon Press, 1931. ISIS

Ruska, Julius. Turba philosophorum. Ein Beitrag zur Geschichte der Alchemie. Bd. I der *Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin*. Hrsg. vom Institut für Geschichte der Medizin und der Naturwissenschaften, redigiert von P. DIEPGEN und J. RUSKA. 368 p., 1 pl. Berlin, SPRINGER, 1931. ISIS

Reviewed by E. O. VON LIPPMANN in *Chemiker-Zeitung*, 55, 867, 1931.

III. ORIENTAL SCIENCE AND CIVILIZATION

8. — ASIA

Western Asia.

Dussaud, René. La mythologie phénicienne d'après les tablettes de Ras Shamra. *Revue de l'Histoire des Religions*, 104, 353-408, 1931. ISIS

Hrozný, Bedřich. L'entraînement des chevaux chez les anciens Indo-Européens d'après un texte mîtannien-hittite provenant du XIV^e^ siècle av. J. C. *Archiv Orientální*. Journal of the Czechoslovak Oriental Institute, Prague. Vol. 3, 431-61, 1931. ISIS

A propos d'un des textes hittites provenant de Boghazkeui. L'auteur, un certain KIKKULISH du pays de Mîtanni y donne des instructions exactes et détaillées concernant l'entraînement des chevaux (env. 1360 av. J.-C.). G. S.

Kammerer, A. Pétra et la Nabatène. L'Arabie pétrée et les Arabes du nord dans leurs rapports avec la Syrie et la Palestine jusqu'à l'Islam. 2 vols. Vol. 1, texte : 620 p., 7 pl., 4 maps, 74 fig., vol. 2, atlas, 152 pl. Paris, GEUTHNER, 1929. ISIS

Reviewed by GEORGE SARTON, *Isis*, 17, 265-67, 1932.

Olmstead, A. T. History of Palestine and Syria to the Macedonian conquest. XXXVI+664 p., 188 fig., 19 maps and plans. New York, SCRIBNER's, 1931. ISIS

Elaborate history well indexed and well illustrated. The legends of the illustrations are insufficient; it is not enough to tell us from which books they were taken; one would like to know where the objects represented are located and to have an idea of their size. The maps of Syria and Palestine at the end of the volume are utterly insufficient, for they give us no idea whatsoever of the altitudes. G. S.

Sprengling, Martin. The heritage of Western Asia. 72 p., ill., map. (*The New Orient Society Monograph* Series, No. 1.) The Open Court, vol. 46, No. 908, January 1932. ISIS

The New Orient Society of Chicago was founded in April, 1930. A series of twelve monographs will appear as alternate numbers of the Open Court magazine during the years 1932 and 1933.

List of proposed monographs : 2. The heritage of Eastern Asia; 3. Modern Turkey; 4. Syria-Palestine; 5. Egypt; 6. Arabia; 7. Persia; 8. Russian and Central Asia; 9. Japan and Korea; 10. India; 11. China; 12. Northern Africa.

A. P.

Central Asia

Bell, Sir Charles. The religion of Tibet. XVI+235 p., pl., port., map. Oxford, Clarendon Press, 1931. ISIS

Eastern Asia

(Including works relative to the whole of Buddhist Asia, or to India, Central and Eastern Asia combined)

Hummel, Arthur W. Chinese, Japanese, and other East Asiatic books added to the Library of Congress, 1930-31. Report of the Librarian of Congress for the fiscal year ending June 30, 1931. Pp. 263-310. Washington, 1931. ISIS

For the previous report, see *Isis*, 16, 534. The present report on the Division of Chinese and Japanese literature includes the *Notes on Japanese accessions*, by Dr. SHIO SAKANISHI (p. 276-290), and the *Notes on Chinese, Korean, and Japanese accessions on materia medica, medicine, and agriculture*, by WALTER T. SWINGLE (p. 290-299). " The number of Chinese works received during the fiscal year was 859, comprising 5,246 volumes, making a total of 142,018 volumes in the Chinese collection on July 1, 1931. The number of *ts'ung shu*, or collections of reprints, received during the year was 10, making a total of 557 now in the Library. The additions in gazeteers number 48, of which 5 are provincial, 10 prefectural, and 33 district—a total of 1,552. The Library has received the first installment of the two great collections of reprints now being issued by the Commercial Press, Shanghai : The *Wan Yu Wen K'u*, and the *Pe Na* edition of the *Twenty-Four Dynastic Histories*." " The accessions to the Japanese collection in the past year comprised 137 works in 195 volumes, 86 of which were cyclopaedias and dictionaries much needed for reference, bringing the total number of volumes in the collection to 12,353."

A. P.

9. — INDIA

Dasgupta, Surendranath. A history of Indian philosophy. Vol. II. XII+620 p. Cambridge, University Press, 1932. ISIS

Datta, Bibhutibhusan. On the relation of MAHĀVĪRA to ŚRĪDHARA. *Isis*, 17, 25-33, 1932. ISIS

Datta, Bibhutibhusan. The origin of Hindu indeterminate analysis. *Archeion*, 13, 401-07, 1931. ISIS

Les premières spéculations des Hindous en analyse indéterminée ont leur origine dans des problèmes que posait la construction des autels sacrificiels védiques : BANDHĀYANA (c. 800 av. J.-C.); APASTAMBA (c. 500 av. J.-C.); KĀTYĀYANA (c. 500 av. J.-C.). L. G.

Gowen, Herbert H. A history of Indian literature from Vedic times to the present day. XVI+593 p. London, APPLETON, 1932. ISIS

Khān, (Khān Sāhib) M. 'ĀBID 'ALĪ, of Māldah (1872-1926). Memoirs of Gaur and Pandua. Edited and revised by H. E. STAPLETON. 190 p., 7 pl., 33 fig. Calcutta, Bengal Secretariat book depot, 1931. (Rs. 5). ISIS

History of the two ancient capitals of Bengal, Gaur, and Pandua, near Angrezābād (English Bāzār). The work originally written by the late KHĀN SĀHIB and now deposited in the library of the Asiatic Society of Bengal was very imperfect and incomplete, and had to be drastically revised for publication. It contains memoirs of the two ancient cities and descriptions of their monuments. The inscriptions are transcribed and translated. There are altogether 63 inscriptions, most of them Arabic, a few Persian, ranging in date from A. D. 1232 to 1721. They illustrate a curious kind of Turko-Perso-Arabic. The book contains also genealogical tables, lists of rulers, an elaborate bibliography, etc. In short, in its present form, it includes all the information which is available on the subject. It is a valuable contribution to our knowledge of Bengal in Muhammedan times. G. S.

Yoga. Internationale Zeitschrift für wissenschaftliche Yoga-Forschung. Vol. I, No. 1, 146 p. Harburg-Wilhelmsburg, Helmut Palmié, 1931. ISIS

Nouvelle revue internationale pour l'investigation scientifique du Yoga, dont le premier fascicule est daté du 1 octobre 1931 et qui annonce cinq numéros par an.

Ce numéro comprend les travaux originaux suivants : Sir JOHN WOODROFFE, Kundalinī Śakti; C. A. F. RHYS DAVIDS, The Fellowman in Yoga; H. COMPERZ, Die psychologische Deutung der Lehre von den Zauberkräften; B. BHATTACARYYA, Sādhana or God-Realisation; R. RÖSEL, Ueber Yoga und verwandte Systeme im Okkultismus der Gegenwart; J. FILLIOZAT, Sur la « concentration oculaire » dans le Yoga; H. VORWAHL, Die Extase in der Literatur der Gegenwart. L. G.

10. — CHINA

Hudson, Geoffrey Francis. Europe and China : a survey of their

relations from the earliest times to 1800. 336 p. London, ARNOLD 1931. ISIS

Partington, J. R. Chinese alchemy, *Nature*, 128, 1074-75, 1931. ISIS

Saussure, Léopold de. Les origines de l'astronomie chinoise. x+ 594+LV p., 39 fig. Paris, MAISONNEUVE, 1930. ISIS

Reviewed by ALEXANDER POGO, *Isis*, 17, 267-71, 1932.

Shryock, John. The temples of Anking and their cults. A study of modern Chinese religion. 206 p., 22 pl. Paris, GEUTHNER 1931 (100 frcs.). ISIS

Contents : Introduction. The temples of Anking. Ancestral temples. Temples to great men. The state temples. Buddhist temples. Taoist temples. Individual cults : The city-god; The dragon king; The fire god; The god who drives away locusts; The god of medicine; The god of wealth; The earth gods. Conclusion. Appendices. Index. Bibliography. "The gods, temples and cults discussed in this paper show the religion of the city, and on the whole, of the more intelligent classes. The religion of the country folk is probably much what it was thousands of years ago, the worship of ghosts and devils (Kuei), of ancestors, and of local tutelary gods. In the main, it is animism, pure and simple. I do not think that either the religion or the social structure of Chinese villages in the real country has ever been adequately investigated, but it must wait for Chinese scholars, since no foreigner could approach the subject with any chance of success. I have not attempted to discuss what DE GROOT calls the sects, because they have no temples. These sects combine elements of different cults with revelations, visions, fasting, the approaching advent of some god like Maitreya, speaking with tongues, and other familiar phenomena. Sometimes they are secret societies, with a political tinge, and come into conflict with the authorities. However, there has been one interesting attempt at conscious syncretism, with which I will close my paper. It was the effort of a Buddhist monk, K'I SUNG, who lived during the reign of SUNG HWANG YU (1049-1053), to combine in one cult the worship of CONFUCIUS, BUDDHA, and LAOTZI. The resultant faith, its popularity and eventual suppression by the authorities, are described by PARKER (Studies in Chinese religion, p. 292 f.). The final decree against it seems to have been issued in 1837."

Waley, A. Notes on Chinese alchemy (supplementary to JOHNSON's *A study of Chinese alchemy*). *Bulletin of the School of Oriental Studies*, London Institution, VI, part 1, 1930. ISIS

Reviewed by TENNEY L. DAVIS, *Isis*, 17, 440-43, 1932.

11. — JAPAN

Katō, Genchi. Le Shintō, religion nationale du Japon. 250 p., 5 pl. (Publication de la Société Zaidan Hōjin Meiji Seitoku Kinen Gakkai,

traduite en français par la Maison Franco-Japonaise de Tōkyō. *Annales du Musée Guimet*, Bibliothèque de vulgarisation, tome 50). Paris, GEUTHNER, 1931 (36 frcs.). ISIS

Extrait de l'avant-propos par SYLVAIN LÉVI : « Le livre de M. G. KATÔ représente l'attitude de la science officielle telle qu'elle veut représenter ' la religion nationale du Japon,' aux yeux du public étranger. Le tableau à dire vrai, jure singulièrement avec l'image du Shintô telle qu'elle est tracée par M. J. M. MARTIN dans une série d'ouvrages qui ont été couronnés par l'Institut. Mais il ne faut pas oublier que si M. KATÔ est le porte-parole de l'orthodoxie officielle, M. MARTIN qui édite ses ouvrages à ' l'Imprimerie de Nazareth,' à Hongkong est un missionnaire apostolique. Le jour où M. KATÔ et M. MARTIN écriront tous les deux sur le Christianisme, les rôles seront curieusement renversés. L'ouvrage de M. KATÔ fait un pendant exact à l'ouvrage que feu le professeur HARA (Kentoku) avait écrit en anglais sur l'histoire du Japon et qui a été publié ensuite dans une traduction française. Tout l'appareil de la critique est mis en œuvre pour consolider la tradition dans ses lignes essentielles. Le lecteur occidental se trouve brusquement transporté au profond de la conscience japonaise, en présence d'un conflit dramatique, on a le droit de dire tragique, entre les exigences de la ' science moderne,' impassible destructrice des idoles, et celles de l'ordre japonais, solidaire de croyances et de traditions qu'il serait téméraire d'ébranler. M. KATÔ qui, en surplus de son érudition japonaise, a lu beaucoup de livres européens, retrouve aisément dans le Shintô toutes les phases de l'évolution religieuse telles qu'elles sont fixées dans le vocabulaire le plus technique de la sociologie et de l'histoire des religions : prépolydémonisme, polydémonisme, animalisme, animisme, fétichisme, phallisme, spiritisme, anthropolatrie, culte des ancêtres, totémisme, polythéisme, théanthropisme, hénothéisme, panthéisme, car il convient que le Japon donne satisfaction à toutes les catégories inventées par l'esprit occidental; mais toutes ces étapes ont pour but d'acheminer le lecteur à la conclusion voulue et indispensable; le Shintô, religion nationale du Japon, vient, grâce à sa ' position unique,' grâce à son ' caractère quasi-universel et semi-propagandiste,' tout doucement se ranger aux côtés du christianisme et du bouddhisme (l'Islam, qui est indifférent au Japon, est de ce fait passé sous silence)."

L'édition anglaise a été publiée en 1926.

Yamamoto, Issei. Japanese astronomy in past and present. Lecture delivered on July 24, 1931, at Kyoto. *Isis*, 17, 425-27, 1932. ISIS

12. — ISRAEL

Duncan, John Garrow. Digging up Biblical history. Recent archaeology in Palestine and its bearing on the Old Testament. The Croall lectures for 1928-1929 amplified. Vol. I, XIII+275 p. Vol. II, XIII+256 p. London, S.P.C.K., 1931. ISIS

Gordon, Hirsch Loeb. The basilica and the stoa in early rabbinical

literature. A study in Near Eastern architecture. *Art Bulletin*, 13, 353—75, 2 fig., 1931. ISIS

Margolis, Max L.; Marx, Alexandre. Histoire du peuple juif des origines jusqu'à nos jours. Traduit de l'anglais par J. ROBILLOT. 752 p., Paris, PAYOT, 1930. ISIS

Ce livre est surtout l'histoire de la vie sociale et économique du peuple juif depuis ses origines jusqu'à nos jours. Après la dispersion du peuple juif, de nombreux centres de groupements ont joué un rôle dans sa vie intérieure et extérieure. Les auteurs ont mis en relief le déplacement de ces centres, de la mère patrie en Orient (Babylone), puis en Europe occidentale (Italie, Espagne, France, Allemagne), après l'expulsion d'Espagne : Amsterdam, Russie, Pologne; enfin un nouvel exode de l'Europe orientale vers les États-Unis et de là, le retour dans l'ancienne patrie (centre sioniste). La fondation de l'Université hébraïque de Jérusalem (1918) favorisa la renaissance de la civilisation juive en Palestine. Presque chaque chapitre comprend l'énumération des persécutions et commentaires de la loi. Le phénomène du messianisme juif de même que l'analyse du phénomène de l'antisémitisme ne sont pas étudiés. Une courte bibliographie et un index terminent ce volume.

L. S.

14. — ISLAM

Abū Muḥammad 'Alī ibn Ḥazm al-Andalusī. The dove's neckring about love and lovers. Composed by ABŪ MUḤAMMAD 'ALĪ IBN ḤAZM AL-ANDALUSĪ. Translated from the unique Ms. in the University of Leiden, edited by D. K. PÉTROF in 1914, by A. R. NYKL. CXXIV+244 p. Chicago, University Press, 1931. ISIS

Reviewed by D. B. MACDONALD, *Isis*, 17, 430-31, 1932.

'Alī, Zakī. Risālat al-ṭibb al-'arabiyi wa tā'thīr fī madaniyat ūrubā. (Arabic medicine and its influence upon European civilization). 44 p. Cairo, National Library, 1931 (in Arabic). ISIS

Popular account including brief sketches of the leading Arabic physicians. Followed by a brief and very imperfect bibliography. The author is a physician attached to the hospital Qaṣr al-'ainī in Cairo. G. S.

Cheikho, Louis. Anciens traités arabes contenant la Politique de THEMISTIUS, l'Economie domestique de PROBUS (?), les Récits amusants de BARHEBRAEUS et l'Exclusion de la tristesse, attribué à PLATON. Tirés de la revue *al-Machriq*. 70 p. Beyrouth, Imprimerie catholique, 1920-23 (in Arabic). ISIS

The PROBUS to whom the second of these treatises was tentatively ascribed is probably the neo-Pythagorean BRYSON, about whom see MARTIN PLESSNER : Der οἰκονομικός des Neupythagoreers BRYSON (Heidelberg, 1928; *Isis*, 13, 529). G. S.

Gottheil, Richard. An illustrated copy of the Koran. *Revue des Etudes Islamiques*, 21-24, 6 pl., 1931. ISIS

Hartner, Willy. Minṭaqa or mintaqat etc., *Encyclopaedia of Islām*, 3, 501-04, 1932. ISIS

Elaborate note on the circle (minṭaqa) of the zodiac. Followed by a comparative table of the Arabic values for the obliquity of the ecliptic.
G. S.

Izzeddine, Cassim. Le choléra et l'hygiène à la Mecque. 119 p. Paris, MALOINE, 1909. ISIS

Meyerhof, Max. Von Alexandrien nach Bagdad : Ein Beitrag zur Geschichte des philosophischen und medizinischen Unterrichts bei den Arabern. 43 p. (Sonderausgabe aus den *Sitzungsberichten der Preussischen Akademie der Wissenschaften*, Phil.-Hist. Classe, XXIII, 1930). Berlin, DE GRUYTER, 1930 (RM. 2.50). ISIS

" Es ist bekannt, dass das Studium der Medizin und der Philosophie, insbesondere das des hippokratisch-galenischen Kanons und des aristotelischen Organons, schon lange vor dem Auftreten des Islams von Alexandrien aus in das sasanidisch-persische Reich eingedrungen war und auf Grundlage syrischer und arabischer Übersetzungen vom VIII. Jahrhundert u. Z. an festen Boden im Chalifenreiche gewonnen hat. Dagegen sind bisher diejenigen arabischen Quellenwerke nicht hinreichend beachtet worden, welche von einer direkten Wanderung des scholastischen Unterrichts, hauptsächlich in der Logik, von Alexandrien über Antiochien und Harrān nach Baghdad in der Zeit von etwa 720 bis 900 n. Chr. berichten. Diese Nachrichten gehen zumeist auf AL-FĀRĀBĪ zurück, der sie von seinen christlichen Lehrern erhalten haben muss. Doch waren auch ihm die Namen der Schulhäupter in Alexandrien und Antiochien schon nicht mehr bekannt. Vielleicht kann diese Lücke in der Wissenschaftsgeschichte noch in Zukunft aus syrischen Dokumenten einmal ausgefüllt werden.

Für die Zeit von etwa 850 bis 1100 n. Chr. ist die Tradition der Schulhäupter und bedeutenderen Lehrer der Philosophie und Medizin ziemlich lückenlos. Sie führt uns von dem letzten ungenannten Schulhaupt in Harrān über QUWAIRĪ, IBRĀHĪM AL-MARWAZĪ, JŪḤANNĀ B. ḤAILĀN, IBN KARNĪB, ABŪ BIŠR MATTĀ, AL-FĀRĀBĪ, JAḤJĀ B. 'ADĪ, IBN AL-ḤAMMĀR, IBN ZUR'A, 'ABDALLĀH B. AṬ-ṬAJJIB und SA'ID B. HIBATALLĀH bis zu IBN ĞAZLA, der ein Zeitgenosse AL-GAZZĀLĪS war, und der seinem philosophischen Unterricht mit dem Übertritt zum Islam bezahlen musste. Der allmähliche Übergang von der Philosophie zur Medizin und von den Syrern zu den Persern ist deutlich erkennbar. Während aber die Stellung eines "Hauptes der Ärzte und Philosophen", welche fast immer Leibärzten der Chalifen vorbehalten blieb, seit dem III./XI. Jahrhundert eine offizielle, vom Herrscher verliehene war, wurde der Titel eines Schulhauptes der Philosophen offenbar rein privat durch die Anerkennung von seiten aller philosophisch Gebildeten den bedeutendsten Gelehrten zuerkannt. Eine staatlich genehmigte Philosophenschule hat in Baghdad der Chalifen ebensowenig existiert wie im

byzantinischen Alexandrien, während offizielle Ärzteschulen, mit Krankenhäusern verbunden, von Chalifen und Ministern mehrfach eingerichtet worden sind. Mit dem Erstarken der Orthodoxie in Baghdad im V./XI. Jahrhundert geht ein deutlicher Verfall der philosophischen Studien einher, die von da an mehr in die kleineren unabhängigen Zentren der islamischen Welt abwanderten."

Miller, Barnette. Beyond the Sublime Porte. The Grand Seraglio of Stambul. With an introduction by HALDÉ EDIB. XXV+281 p., 69 plans, illus. New Haven, Yale University Press. ISIS

Reviewed by D. B. MACDONALD, *Isis*, [illegible], 439-40, 1932.

Palacios, Miguel Asín. El Islam cristianizado. Estudio del " Sufismo " a través de las obras de ABENARABI de Murzia. Dibujos de CARLOS DE MIGUEL. 541 p., 2 pl., maps. Madrid, Editorial Plutarco, 1931. ISIS

Reviewed by GEORGE SARTON, *Isis*, 17, 271-73, 1932.

Thomas, Bertram. Arabia Felix : across the empty quarter of Arabia. Foreword by T. E. LAWRENCE and appendix by Sir ARTHUR KEITH. XXIX+397 p., ill., maps. London, CAPE, 1932. ISIS

PART III

SYSTEMATIC CLASSIFICATION

Including only the material which could not be included in Parts I and II. Hence studies on Japanese astronomy or on XIIIth century astronomy are not classified below under astronomy, but above, respectively under Japan (in Part II) and XIIIth century (in Part I).

The sections forming Part III are classified as follows :

I. *Science in general:* 15. Bibliography; 16. History; 17. Organization; 18. Philosophy.

II. *Formal sciences* (Knowledge of forms) : 19. Logic and Theory of Knowledge; 20. Mathematics; 21. Statistical methods.

III. *Physical sciences* (Knowledge of inorganic nature) : 22. Mechanics; 23. Astronomy; 24. Physics; 25. Chemistry (physico-chemistry, industrial chemistry); 26. Technology.

IV. *Biological sciences* (Knowledge of organic nature) : 27. Biology (generalities, " natural history "); 28. Botany (agronomy, phytopathology, palaeobotany); 29. Zoology.

V. *Sciences of the earth* (Implying knowledge of both organic and inorganic nature) : 30. Geodesy; 31. Geography and Oceanography; 32. Geology, Mineralogy, Palaeontology, Mining; 33. Meteorology, Climatology, and Terrestrial Physics.

VI. *Anthropological and historical sciences* (Knowledge of man, past and present) : 34. Anatomy; 35. Physical anthropology (anthropometry and races of man); 36. Physiology (human and comparative); 37. Psychology (human and comparative); 38. Archaeology (generalities, methods); 39. Prehistory; 40. Ethnology (primitive and popular science); 41. Superstition and Occultism. 42. Economics (economic doctrines and history; commerce; transportation and communications); 43. Sociology, Jurisprudence and Positive polity; 44. History of Civilization (general history, historical methods, biography and chronology); 45. History of Art (art and science; iconography; arts and crafts); 46. History of Language, Writing and Literature; 47. History of Morals (moral organization of society); 48. History of Philosophy; 49. History of Religion (science and religion).

VII. *Medicine :* 50. History, organization and philosophy of Medicine; 51. Epidemiology, History of special diseases. Public health and Social medicine; 52. History of hospitals and of medical teaching; 53. Pharmacy, Pharmacology, Toxicology.

VIII. *Education* (The methods of accumulating, imparting and diffusing knowledge) : 54. Education (generalities, methods, colleges, universities); 55. Academies, Societies, Congresses. National and international organization of science; 56. Bibliography (methods, libraries); 57. Museology (museums and collections).

IX. 58. Alia; 59. Errata.

The applied sciences are not disconnected from the pure sciences, but, as far as possible, the principles and applications of science are considered in the same section. However, applications based upon the principles of many sciences are dealt with separately (e.g. technology; medicine; education).

I. SCIENCE IN GENERAL

16. — HISTORY OF SCIENCE

Carnegie Institution, Section of the History of Science. Thirteenth annual report for the period extending from July 1, 1930 to June 30, 1931. *Isis*, 17, 209-17, 1932. ISIS

(History of Science). Comité international d'histoire des sciences. *Archeion*, 13, 339-69, 1931. ISIS

Compte-rendu des séances (troisième réunion du Comité), tenues à Londres (28 juin-2 juillet). La quatrième réunion du Comité a eu lieu à Paris du 13 au 16 mai 1932.

(History of Science). VII[e] Congrès international des sciences historiques. Section d'histoire des sciences et de la médecine. Deuxième communiqué de la commission organisatrice. *Isis*, 17, 421-23, 1932. ISIS

(History of Science). L'enseignement de l'histoire des sciences. *Archeion*, 13, 467-90, 1931. ISIS

MIELI groupe sous ce titre : 1. La bibliographie, par pays, des notes relatives à cette question parues dans *Archeion* depuis 1929; 2. Les communications et raports lus au Congrès de Londres le 30 juin 1931, par MIELI, D. E. SMITH, G. LORIA, Q. VETTER, L. DE PINA, V. L. BOLOGA.

(History of Science). L'enseignement de l'Histoire des Sciences. *Archeion*, 14, 88-110, 161-62, 1932. ISIS

Ensemble de courtes notes, dont certaines ont été lues au deuxième Congrès d'Histoire des Sciences, Londres, 1931 : F. DANNEMANN, The teaching of sciences in the synthetical way; F. H. HAYWARD, The teaching of the history of science ; A. E. HEATH *(id.)* ; F. S. MARVIN *(id.)* ; J. PELSENEER, Cours d'histoire des sciences physiques et mathématiques à l'université libre de Bruxelles; QUIDO VETTER, Cours d'histoire des sciences (Praha); FRANCISCO VERA, La enseñanza de la historia de las sciencias en España; PIERRE BRUNET : L'enseignement de l'histoire des sciences en France; A. WOLF : Teaching of the history of science at the university of London; M. STEPHANIDES : L'histoire des sciences en Grèce; LUJO THALLER : Geschichte der Medizin und der Tierarzneikunde an den Universitäten Jugoslawiens; A. BIRKENMAJER : L'enseignement de l'histoire des sciences et de la médecine en Pologne; Institut d'histoire des sciences de l'université de Paris; etc. L. G.

Langevin, P. La valeur éducative de l'histoire des sciences. *Bulletin de la Société française de pédagogie*, 692-700, décembre 1926. ISIS

Maynard, Katherine. Science in early English literature, 1550-1650. *Isis*, 17, 94-126, 1932. ISIS

Meyerson, Emile. De l'étude de l'histoire des sciences. *Archeion*, 13, 297-99, 1931. ISIS

Message envoyé au deuxième Congrès international d'histoire des sciences, Londres, juin 1931.

Picard, Emile. Eloges et discours académiques. VIII+400 p. Paris, GAUTHIER-VILLARS, 1931. ISIS

Reviewed by GEORGE SARTON, *Isis*, 17, 443, 1932.

Sarton, George. The History of Science and the New Humanism. 178 p. New York, HOLT, 1931. ISIS

Reviewed by PH. DEVAUX in *Revue de l'Université de Bruxelles*, 70-75, 1931; by HÉLÈNE METZGER, *Revue philosophique*, 114, 144-45, 1932; also discussed by ERNST ZINNER in his Untersuchungen zur Geschichte der Sternkunde, p. 48-57 (Sonderabdruck aus XXVI. *Bericht der Naturforschenden Gesellschaft* in Bamberg, 1932).

Sarton, George. Introduction to the History of Science. Vol. II :

From RABBI BEN EZRA to ROGER BACON. In two parts. XXXV+ 1251 p. Baltimore, WILLIAMS and WILKINS, 1931. ISIS

Reviewed by E. O. VON LIPPMANN, *Chemiker-Zeitung*, 249, 1932; by HÉLÈNE METZGER, *Revue philosophique*, 114, 144-45, 1932 and in *Revue scientifique*, 114, 145-46, 1932; by ALDO MIELI, *Archeion*, 14, 123-26, 1932; by ANGEL GONZALEZ PALENCIA in *El Debate*, Madrid, Sábado 16 de abril de 1932; by HENRY R. VIETS, *The New England Journal of Medicine* (vol. 206, 131, 1932, editorial).

(Sarton, George ; Pogo, Alexander). Thirty-second critical bibliography of the history and philosophy of science and of the history of civilization (to October 1931). *Isis*, 17, 468-634, 1932. ISIS

17. — ORGANIZATION OF SCIENCE

(Internal organization is meant, see Isis, 1, 195. *For external organization, national or international, see section* 55.)

Natucci, A. Specimine de classificatione de scientias. *Schola et Vita*, 6, 241-43, 1931. ISIS

A. Scientias generale : I. Mathematica. II. Physico-chemicos : 1. Physica de molecula; 2. Physico-chemia; 3. Physica de atomo (Chemia); 4. Radiologia; 5. Physica de electrone. B. Scientias particulare : I. Astronomia aut cosmologia : 1. Mechanica caeleste; 2. Astrophysica. II. Geologia (in sensu lato) : 1. Geographia physico; 2. Meteorologia; 3. Mineralogia; 4. Geologia historico. III. Biologia : 1. Zoologia; 2. Botanica; 3. Protistologia; 4. Palaeontologia; 5. Anatomia comparato. IV. Anthropologia (in sensu lato) : 1. Anthropologia (in sensu stricto); 2. Ethnographia; 3. Palaeoethnographia; 4. Archaeologia; 5. Oeconomia; 6. Statistica; 7. Historia.

18. — PHILOSOPHY OF SCIENCE

Crum, Ralph B. Scientific thought in poetry. VI+246 p. (Columbia University studies in English and comparative literature). New York, Columbia University Press, 1931. ISIS

Devaux, Ph. Savants et philosophes. *Revue de l'Université de Bruxelles*, 67-75, 1931. ISIS

Apropos of recent studies by P. BRUNET, J. PELSENEER, Mme H. METZGER, G. SARTON, etc. Including an elaborate discussion of the latter's reformation of university studies as outlined in his book The History of Science and the New Humanism (New York, 1931).

Jeans, Sir James H. Le mystérieux univers. Traduit de l'anglais par M. BILLANDEL et J. ROSSIGNOL. XII+172 p., 1 port., 2 pl., Paris, HERMANN & Cie, 1931. ISIS

Cet ouvrage fait suite à l'*Univers* (trad. de G. CROS, PAYOT, édit.) publié en 1930 (*Isis*, 18, 395). L'édition anglaise en a précédemment été signalée (*Isis*, 14, 541; 16, 547). Il contient le développement de la conférence Rede faite à l'Université de Cambridge en novembre 1930. Les quatre premiers chapitres, qui forment la partie principale du livre, contiennent de brèves discussions sur « le soleil qui se meurt, le monde nouveau et la physique moderne, matière et rayonnement, la relativité et l'éther ». Le dernier chapitre donne les interprétations philosophiques que l'auteur attribue aux faits scientifiques et aux hypothèses discutées dans la partie principale. Il se montre plutôt partisan de la mécanique ondulatoire de DE BROGLIE et de SCHRÖDINGER que des systèmes de HEISENBERG ou de DIRAC (*Isis*, 15, 257).

L. G.

Lichtenstein, L. La philosophie des mathématiques selon M. EMILE MEYERSON. *Revue philosophique*, 57, 169-206, 1932. ISIS

Northrop, F. S. C. Science and first principles. XIV+299 p. New York, MACMILLAN, 1931. ISIS

Reviewed by H. T. DAVIS, *Isis*, 17, 273-77, 1932.

II. FORMAL SCIENCES
(Knowledge of forms)

19. — LOGIC AND THEORY OF KNOWLEDGE

Hilbert, D. La connaissance de la nature et la logique. *L'enseignement mathématique*, 30, 22-33, 1931. ISIS

Jørgensen, Jørgen. A treatise of formal logic : its evolution and main branches, with its relations to mathematics and philosophy. Vol. 1. XV+266 p. Vol. 2. IV+273 p. Vol. 3. IV+321 p. Copenhagen, LEVIN and MUNKSGAARD, 1931. ISIS

Reviewed by THOMAS GREENWOOD, *Nature*, 128, 1021-23, 1931.

Meyerson, Emile. Du cheminement de la pensée. 3 vol. XXVII+294+422+320 p. (*Bibliothèque de philosophie contemporaine*). Paris, ALCAN, 1931. ISIS

Reviewed by HÉLÈNE METZGER, *Isis*, 17, 444-45, 1932.

20. — MATHEMATICS

Helmholtz, Hermann von (1821-94). Counting and measuring. Translated by CHARLOTTE LOWE BRYAN, with an introduction and notes by HAROLD T. DAVIS. XXXIV+39 p. New York, VAN NOSTRAND, 1930. ISIS

Reviewed by P. A. SMITH in *Bulletin Amer. Math. Society*, 38, 13, 1932.

Koppelmann, Dr. Ostasiatische Zahlwörter in südamerikanischen Sprachen. Leiden, *Inter. Archiv. für Ethnographie*, 30, 77-94, 1929. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 121, 1930.

Loria, Gino. L'ininterrotta continuità del pensiero matematico italiano. *Period. Mat.*, 4, 1-16, 1932. ISIS

Luquet, G. H. Sur l'origine des notions mathématiques. Remarques psychologiques et ethnographiques. Paris, *Journal de psychologie normale et pathologique*, 15, 733-62, 26 fig., 1929. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 123-24, 1930.

Marcolongo, Roberto. La matematica di quaranta secoli fa. *Scientia*, 51, 21-34, 1932. ISIS

Padoa, Alessandro. Il problema di ALHAZEN studiato elementarmente. *Periodico di matem.*, 113-18, mars 1932. ISIS

Pelseneer, Jean. A propos de notations mathématiques. *Isis*, 17, 259, 1932. ISIS

Ribeiro dos Santos, Antonio. Memorias historicas sobre alguns mathematicos Portuguezes, e estrangeiros domiciliarios em Portugal, ou nas conquistas. *Academia das sciencias de Lisboa. Memorias*, 8, 148-229, 1812. ISIS

Scardapane, Nicoletta Maria. Il problema di MALFATTI. *Periodico di mat.*, 281-93, 1931. ISIS

Welborn, Mary Catherine. Ghubār numerals. *Isis*, 17, 260-63, 1932. ISIS

III. PHYSICAL SCIENCES

(Knowledge of inorganic nature)

23. — ASTRONOMY

Bailey, Solon I. The history and work of Harvard Observatory, 1839-1927. (*Harvard Observatory monographs*, no. 4). New York, MCGRAW-HILL, 1931. ISIS

Reviewed by FREDERICK E. BRASCH, *Science*, 74, 598-99, 1931.

Bruhat, Georges. Le soleil. XII+241 p., 47 fig., 16 pl. *Nouv.*

collection scientifique de EMILE BOREL, Paris, ALCAN, 1931 (20 fr.).

ISIS

Exposé de l'état de nos connaissances sur le soleil, sans grand développement mathématique. Les deux premiers chapitres traitent, après quelques considérations générales, du rayonnement et de la température du soleil, des fluctuations possibles de cette température et de leur répercussion sur les phénomènes terrestres. Au chapitre III sont établies par différentes méthodes les lois de la rotation de la surface solaire. Les chapitres suivants sont relatifs au spectre normal du soleil, au spectre de la chromosphère, aux taches, à la couronne, aux actions électriques et magnétiques du soleil. Et chaque fois sont développés les faits d'observation et les conséquences qui en découlent, en les intégrant dans le cadre général des théories physiques; mais chaque fois aussi sont exposées les insuffisances des théories actuelles.

L'auteur, professeur à la faculté des sciences de l'Université de Paris, a laissé de côté la question de l'état des masses internes du soleil, celles de l'entretien de son énergie et de son évolution, questions qui ne peuvent pas être résolues par l'observation même du soleil, et qui ne peuvent être abordées utilement que dans le cadre beaucoup plus vaste de l'étude du monde stellaire. L. G.

Doublet, E. Les observatoires du Parc de Montsouris. *Revue scientifique*, 20-22, 1932. ISIS

Hagen, J. G. The history of cosmic clouds. *Scientia*, 51, 133-36, 1932 ; traduction française, *ibid.*, supplém., 81-85). ISIS

Les champs nébuleux étendus d'HERSCHEL, les taches sombres décrites d'une part par SECCHI (1877) et d'autre part par BARNARD (1884) et les nuées cosmiques étudiées systématiquement à Rome par HAGEN et ses collaborateurs, sont les mêmes nébulosités. L. G.

Hale, George Ellery. Signals from the stars. XX+138 p., front., 56 figs. New York, SCRIBNER'S, 1931. ($ 2.00). ISIS

After an interval of five year, the SCRIBNER'S series of Dr. HALE'S essays — *The New Heavens*, 1922 (*Isis*, 5, 281); *The Depths of the Universe*, 1924 (*Isis*, 7, 152-53); and *Beyond the Milky Way*, 1926 (*Isis*, 9, 570)—is continued in this little volume. It contains four essays, based on papers which appeared in *Scribner's* and *Harpers* magazines and in *Popular Astronomy:* I. The possibilities of large telescopes; II. Exploring the solar atmosphere; III. Signals from the Sun; IV. Building the 200-inch telescope. Although the primary purpose of these essays is to acquaint the educated laymen with solar research and with large reflectors, readers who are interested in the history of science will appreciate their autobiographical value. The history of solar research since the beginning of the last decade of the XIXth century is inextricably interwoven with the biography of the organizer of the Kenwood and the Yerkes observatories, and of the great research institutions in Pasadena and on Mount Wilson. Interesting sketches (chiefly by RUSSELL W. PORTER) and numerous photographs illustrate the fascinating story told in these essays. A. P.

Humbert, P. Les erreurs astronomiques des littérateurs. *Revue des questions scientifiques*, 13, 396-418, 1928. ISIS

Rome, A. Sur une loi empirique des éclipses de lune. *Annales de la Société scientifique de Bruxelles*, 51, 94-103, 1931. ISIS

« Les éclipses possibles se succèdent à des intervalles de cinq et de six lunaisons. Cette loi peut se découvrir rien qu'en considérant une liste suffisamment longue de dates auxquelles on a observé des éclipses de lune. On trouve des traces de son utilisation par les Babyloniens. Ils ont possédé des cycles d'éclipses possibles. Ces cycles ont été repris par HIPPARQUE (Cat. cod. astr. gr. $VIII_2$ p. 126, 25-27) qui les a utilisés à titre de première approximation vraisemblablement, mais qui a peut-être aussi recommandé l'emploi de la loi des cinq et six mois à titre de moyen de fortune pour prédire les éclipses. En tous cas, ce moyen de fortune est préconisé par HÉRON D'ALEXANDRIE (Dioptra, éd. SCHÖNE, p. 302, 17-22) ».

Vallicrosa, J. Millàs. La introducción del cuadrante con cursor en Europa. *Isis*, 17, 218-58, 6 pl., 1932. ISIS

24. — PHYSICS

Burr, Alex. C. Conductivity. Query no. 20. *Isis*, 17, 427, 1932. ISIS

Eddington, Arthur Stanley. La nature du monde physique. Trad. de l'anglais par GEORGES CROS. 352 p. Paris, PAYOT, 1932. ISIS

Exposé des conceptions du monde physique, nées des théories d'EINSTEIN et de MINKOWSKI, de RUTHERFORD, de BOHR, de PLANCK, etc., et des conséquences philosophiques qui en dérivent. L. G.

Manley, R. M. Synthetische Naturerkenntnis. 66 p., 3 fig. Cleveland, 1931. ISIS

Reviewed by E. O. VON LIPPMANN, *Chemiker-Zeitung*, 55, 821, 1931.

Planck, Max. Der Kausalitäts-Begriff in der Physik. 26 p. Leipzig, BARTH, 1932. ISIS

Reviewed by E. O. VON LIPPMANN, *Chemiker-Zeitung*, 56, 435, 1932.

25. — CHEMISTRY, PHYSICO-CHEMISTRY, INDUSTRIAL CHEMISTRY

Boutaric, A. Les colloïdes et l'état colloïdal. 258 p., ill. *Nouv. collection scientifique*, de EMILE BOREL. Paris, ALCAN, 1931 (18 fr.). ISIS

Mise au point des leçons que consacre aux colloïdes l'auteur dans son

cours de chimie physique à l'Université de Dijon. Il s'est « surtout efforcé de dégager de l'ensemble un peu touffu et parfois incohérent des faits qui ont été signalés, ceux qui présentent un certain degré de généralité ».

Au point de vue historique, BOUTARIC rappelle que si c'est bien THOMAS GRAHAM (1861) qui a mis en évidence les propriétés fondamentales des colloïdes, indiqué le moyen de les isoler par dialyse et créé la terminologie employée à leur sujet, c'est A. BAUDRIMONT (1806-1880) qui a le premier, entre 1844 et 1846, étudié les propriétés de toute une catégorie de substances qu'il appelait particulaires ou incristalisables, et dont il distinguait nettement les solutions des solutions ordinaires, et que vers la même époque, FRANCESCO SELMI étudiait aussi les solutions colloïdales sous le nom de pseudo-solutions.

L. G.

Lippmann, Edmund O. von. Weiteres über Herkunft und Rolle der pflanzlichen Aschen-Bestandteile. *Chemiker-Zeitung*, 56, 2, 1932. ISIS

Walden, Paul. Mass, Zahl und Gewicht in der Chemie der Vergangenheit : ein Kapitel aus der Vorgeschichte des sogenannten quantitativen Zeitalters der Chemie. 106 p. (*Sammlung chemischer und chemisch-technischer Vorträge*. Neue Folge, H. 8.) Stuttgart, ENKE, 1931. ISIS

Reviewed by CHARLES ALBERT BROWNE, *Industrial and Engineering Chemistry*, 24, 596, 1932; by E. O. v. LIPPMANN, *Chemiker-Zeitung*, 55, 927, 1931.

Weeks, Mary Elvira. The discovery of the elements. Foreword. I. Elements known to the ancient world. *Journal of Chemical Education*, 9, 3-10 ; II. Elements known to the alchemists, *ibid.*, 9, 11-21 ; III. Some eighteenth century metals, *ibid.*, 9, 22-30 ; IV. Three important gases, *ibid.*, 9, 215-35; V. Chromium, molybdenum, tungsten, and uranium, *ibid.*, 9, 459-73 ; VI. Tellurium and selenium, *ibid.*, 9, 474-85 ; VII. Columbium, tantalum, and vanadium, *ibid.*, 863-84 ; VIII. The platinum metals, *ibid.*, 9, 1034 ; IX. Three alkali metals : potassium, sodium, and lithium, *ibid.*, 9, 1035-45 ; X. The alkaline earth metals and magnesium and cadmium, *ibid.*, 9, 1046-57, 1932. ISIS

An interesting narrative account, well documented and illustrated.

T. L. D.

26. — TECHNOLOGY

(*For mining, see* 32. *Geology* ; *for industrial chemistry,* 25. *Chemistry. See also Arts and crafts under* 45.)

Bogaert, Ed. W. Un peu d'histoire (Les sciences mécaniques en

Belgique pendant un siècle). *Bulletin technique de l'association des ingénieurs sortis de l'Ecole Polytechnique de Bruxelles*, 27, 23-33, 1931. ISIS

Cromer, G. Quelques épreuves et documents relatifs à l'histoire de la photographie panoramique. *Bul. soc. fr. photogr.*, 17, 170-82, 1931. ISIS

Laird Clowes, G. S. Sailing ships, their history and development as illustrated by the collection of ship models in the Science Museum. Part I. Historical notes. 110 p. London, H. M. Stationery Office, 1930. ISIS

Reviewed by H. H. BOOTES, *Geographical Journal*, 78, 85-87, 1931. "Mr. LAIRD CLOWES has adopted the chronological and geographical method, giving a general account of the vessels of a country and age as a whole."

Lefebvre des Noëttes, Ct. L'attelage, le cheval de selle à travers les âges. Contribution à l'histoire de l'esclavage. Préface de JÉROME CARCOPINO. 2 vol. VIII+312 p., 46 fig. dans le texte, 457 photo. hors texte. A. PICARD, Paris, 1931. ISIS

Ouvrage important dont la première édition, sensiblement différente de celle-ci (l'illustration a passé de 217 fig. à plus de 500) a paru en 1924 sous le titre « La force animale à travers les âges » (*Isis*, 9, 575). Partant de questions aussi spéciales que celle de l'attelage des animaux de trait, de la ferrure, du collier, de la bride, etc., examinées à la lumière des textes et surtout des documents figurés, l'auteur démontre que la route romaine, ce chef-d'œuvre tant vanté, était impropre tant à l'agrément des voyages individuels qu'à la circulation commerciale (*Isis*, 8, 585); que malgré les ferrures présentées comme romaines ou mérovingiennes dans certains musées, la ferrure à clous n'est connue qu'au début du X^e^ siècle; qu'enfin, le collier d'épaules, qui seul permet à l'attelage un rendement satisfaisant, date de la même époque. Mais ses conclusions dépassent singulièrement le cadre de la traction animale.

De l'état rudimentaire de la technique des transports par route, il déduit l'inéluctable nécessité du portage humain; cette insuffisance de la traction animale se trouve être la cause principale de l'esclavage, qui s'étiole et meurt en Occident au moyen-âge, sans aucune intervention légale, lorsqu'il devient inutile, et réapparaît dans toute sa rigueur au XVI^e^ siècle en Amérique, pour les mêmes raisons qui motivaient son existence dans le monde antique.

La deuxième partie de l'ouvrage, relative au cheval de selle, ne permet pas de conclusion de cette envergure. L. G.

Magoun, Frederick Alexander; Hodgins, Eric. A history of aircraft. XX+495 p. New York, MCGRAW-HILL, 1931. ISIS

(Radio). A chronological history of electrical communication, telegraph, telephone, and radio. *Radio Engineering*, 12, 6, 1932. ISIS

Straker, Ernest. Wealden iron. XIV+488 p. London, BELL, 1931. ISIS

Reviewed by S. E. WINBOLT, *Geographical Journal*, 78, 365, 1931. "The first authoritative and comprehensive account of the Sussex, Surrey, and Kent ironworks. The story begins with bloomeries, pre-Roman, Roman, and Mediaeval, continues with the evolution of the blast furnace in the Tudor period, and of the industry through Stuart and Hanoverian times."

C. W. A.

Testi, Gino. Le antiche miniere di allume e l'arte tintoria in Italia. *Archeion*, 13, 440-48, 1931. ISIS

Vowles, Hugh P. Early evolution of power engineering. *Isis*, 17, 412-20, 4 pl., 1932. ISIS

IV. BIOLOGICAL SCIENCES

(Knowledge of organic nature)

27. — BIOLOGY

(*Generalities*, "*Natural history*")

Needham, Joseph. The sceptical biologist. 270 p. New York, NORTON, 1930. ISIS

Reviewed by ADOLF MEYER, *Isis*, 17, 277-78, 1932.

Newman, Horatio Hackett. Evolution yesterday and today. X+171 p. (A Century of Progress series.) Baltimore, WILLIAMS & WILKINS, 1932 ($ 1.00). ISIS

A brief impartial but critical summary of past concepts and current tendencies in evolutionary thought and investigation. C. A. K.

Nicolle, Charles. Biologie de l'invention. XVI+162 p., Paris, ALCAN, 1932. ISIS

Le savant directeur de l'Institut Pasteur de Tunis, dont le nom restera attaché à la découverte du spirochète du typhus exanthématique, nous livre quelques unes des réflexions auxquelles l'a amené sa pratique déjà longue de l'invention, le mot étant pris ici au sens large. Elles sont groupées sous 3 chefs : l'esprit d'invention, l'école de l'inventeur, l'avenir de l'esprit d'invention. Inutile de dire que, biologiste, NICOLLE donne surtout des exemples tirés des travaux des biologistes, et en particulier de ceux de PASTEUR. L'esprit d'invention, nous dit-il, offre les caractères d'un accident; il se développera sous l'action de circonstances qui dérangent la tendance à l'équilibre qui est la caractéristique de la vie; l'acte créateur a un caractère irrationnel. Quant aux facteurs qui interviennent dans l'acte d'invention, ce sont ceux

qui favorisent les associations imprévues d'idées ou d'images. Les ennemis de la découverte sont le respect des idées acquises, l'érudition. Antagoniste aussi de l'invention, l'évolution de notre société qui tend de plus en plus vers un équilibre, vers une moyenne destructrice de l'originalité, « vers une fin monstrueuse où les fonctions, la pensée prendront un caractère collectif ». Le second chapitre est plus particulièrement consacré à la psychologie de l'inventeur, et des « larrons » qui leur disputent, soit le mérite de la découverte, soit les maigres profits qu'elle pourrait leur rapporter. L. G.

Nieuwenhuis, Anton Willem. Die Anfangsformen der Naturwissenschaften in Ozeanien. Die dualistische Naturbetrachtung. *Janus*, 35, 17-58, 1931. ISIS

Piney, A. Recent advances in microscopy. Biological applications. Edited by A. PINEY. Medicine, by A. PINEY ; The living eye, by BASIL GRAVES ; Zoology, by E. W. MACBRIDE and R. R. HEWER ; and Botany, E. C. BARTON-WRIGHT. VIII+260 p., 83 figs. Philadelphia, BLAKISTON, 1931. ISIS

Reviewed by CHARLES A. KOFOID, *Isis*, 17, 446-47, 1932.

Streeter, George L. Annual report of the director of the department of embryology. 36 p. Carnegie Institution of Washington, Year Book no. 30 for the year 1930-31, p. 3-36, 1931. ISIS

Tracy, Henry Chester. American naturists. VIII+282 p. New York, DUTTON, 1931. ISIS

Reviewed by CHARLES A. KOFOID, *Isis*, 17, 445-46, 1932.

29. — ZOOLOGY

Essig, E. O. A history of entomology. X+1029 p., 263 figs. New York, MACMILLAN, 1931. ISIS

Reviewed by CHARLES A. KOFOID, *Isis*, 17, 447-50, 1932.

Heape, Walter. Emigration, migration, and nomadism. Edited with a preface by F. H. A. MARSHALL. XII+369 p. Cambridge, HEFFER, 1931. ISIS

Howard, Leland Ossian. The insect menace. XV+347 p., front., illus., pl. London, APPLETON, 1931. ISIS

Vallisnieri, Antonio. Observations on the fly of rosebushes and other insects of the same habitat. Translated by MAB BIGELOW and revised by R. P. BIGELOW. *Isis*, 17, 290-324, 4 pl., 1932. ISIS

V. SCIENCES OF THE EARTH

(Implying knowledge of both organic and inorganic nature.)

31. — GEOGRAPHY AND OCEANOGRAPHY

Baker, John Norman Leonard. A history of geographical discovery and exploration. 544 p. (*Harrap's New Geographical Series.*) London, HARRAP, 1931. ISIS

Karpinski, Louis C. Bibliography of the printed maps of Michigan, 1804-1880; with a series of over one hundred reproductions of maps constituting an historical atlas of the Great Lakes and Michigan. Including discussions of Michigan maps and map-makers by WILLIAM LEE JENKS. 539 p., maps. Lansing, Michigan Historical Commission, 1931. ISIS

This is a comprehensive bibliography of maps of Michigan, 1804-1880, covering general maps of the state, maps of its several counties, towns and cities, U. S. government maps, special maps of all kinds, and maps in school geographies and atlases. In addition, Professor KARPINSKI gives a running account of the more important earlier maps of the Great Lakes and Michigan. From this and from many half tone and line cut reproductions of significant maps we may trace the cartographical history of the region from the first appearance of the Lakes on GERARD MERCATOR's map of 1569 until their outlines had assumed definitive form early in the nineteenth century. There is also included a chapter by W. D. JENKS on the FARMER family (JOHN FARMER (1795-1859), his son SILAS FARMER (1839-1902), and grandson ARTHUR FARMER), who for three generations were engaged in the business of compiling and publishing maps. Although in Europe there have been many distinguished cartographical families—notably those of the MERCATOR, BLAEU, SANSON, and HOMANN—in America only the FARMERS and the HOENS of Baltimore have had a comparable record. The FARMERS specialized in maps of Michigan. J. K. W.

VI. ANTHROPOLOGICAL AND HISTORICAL SCIENCES

(Knowledge of man, past, and present)

35. — PHYSICAL ANTHROPOLOGY

(*Anthropometry and races of man*)

Breuil, H. Le gisement du sinanthropus à Chou-Kou-Tien (Chine), restes de feu et d'industrie. *Revue scientifique*, 70, 171-74, 1932. ISIS

Pina, Luís de. Materiais para a antropologia de Moçambique. *Arquivo de Anatomia e Antropologia*, 14, 113-25, 1931. ISIS

Pina, Luís de. Observações sobre a morfologia da orelha nos Portugueses. *Arquivo de Anatomia e Antropologia*, 14, 91-105, 2 fig., 8 tables, 1931. ISIS

Teilhard de Chardin, Pierre. Le « Sinanthropus » de Pékin. Etat actuel de nos connaissances sur le fossile et son gisement. *L'anthropologie*, 41, 1-12, 1931. ISIS

37. — PSYCHOLOGY (*human and comparative*)

Janssens, Edg. Scientisme et vérité historique. Réponse à « L'âme des bêtes » de M. le Professeur VERLAINE. 158 p. Liége, La pensée catholique, 1932. ISIS

Ouvrage de polémique. L'auteur reproche à VERLAINE (voir ci-dessous) de manquer d'esprit historique, de trop estimer les méthodes actuelles de recherches et les théories actuelles; il lui reproche enfin « la passion anti-religieuse qui l'anime, particulièrement envers le catholicisme ».

L. G.

Lévy-Bruhl, Lucien. La mentalité primitive. Une Herbert Spencer lecture. 27 p. Oxford, University Press. ISIS

Reviewed by HÉLÈNE METZGER, *Isis*, 17, 450-53, 1932.

Lévy-Bruhl, Lucien. Le surnaturel et la nature dans la mentalité primitive. XL+526 p. (*Bibliothèque de philosophie contemporaine.*) Paris, ALCAN, 1931. ISIS

Reviewed by HÉLÈNE METZGER, *Isis*, 17, 450-53, 1932.

Montmasson, Joseph-Marie. Invention and the unconscious. Translated, with a preface, by H. STAFFORD HATFIELD. XXIV+338 p. (*International Library of Psychology, Philosophy and Scientific Method.*) London, KEGAN PAUL, 1931. ISIS

Verlaine, L. L'âme des bêtes; quelques pages d'histoire. 202 p., Paris, ALCAN, 1931. ISIS

L'auteur, chargé de cours de physiologie à l'université de Liége, nous donne dans cet ouvrage, au titre un peu énigmatique, une histoire de la psychologie comparée, ou plus exactement, une histoire des tâtonnements et des erreurs de la psychologie comparée avant qu'elle parvienne, dans les dernières années du XIX^{e} siècle, à s'élever au niveau d'une science véritable, expérimentale, possédant un objet propre et des méthodes particulières. Il considère comme le premier ouvrage de psychologie comparée les *Lettres philosophiques sur l'intelligence et la perfectibilité des animaux*, publiées de 1762 à 1771 par GEORGES LEROY, disciple de CONDILLAC, que ses fonctions de lieutenant des chasses royales mettaient à même d' « amasser des trésors

d'observations originales, de faits précis, fort bien analysés, et interprétés avec beaucoup d'objectivité ». Cet ouvrage sur l'âme des bêtes sert en quelque sorte d'introduction à une série d'études de psychologie animale que se propose de publier L. VERLAINE, pour « contribuer à la restauration de la philosophie de la Nature, au triomphe du Libre Examen ». (Voir ci-dessus : JANSSENS, EDG.). L. G.

Woodworth, Robert Sessions. Contemporary schools of psychology. VIII+247 p. London, METHUEN, 1931. ISIS

39. — PREHISTORY

Capitan, L. La préhistoire. Edition revue et augmentée par MICHEL FAGNET ; préface de HENRI BREUIL. 223 p., fig., 16 pl. Paris, PAYOT, 1931 (24 frs.). ISIS

L'édition de 1922 de l'admirable manuel du savant aujourd'hui disparu a été développée, mise à jour et enrichie de remarquables photographies; excellente bibliographie. Tout cours sur l'histoire des sciences devrait commencer par la mention des ouvrages de BOULE (Les hommes fossiles, troisième édition 1928), CAPITAN, et LUCIEN LÉVY-BRUHL (Les fonctions mentales dans les sociétés inférieures, 1910; La mentalité primitive, 1922; L'âme primitive, 1927; Le surnaturel et la nature dans la mentalité primitive, 1931). J. P.

Leakey, Louis Seymour Bazett. The stone age cultures of Kenya Colony. Appendices by J. D. SOLOMON, C. E. P. BROOKS, A. T. HOPWOOD, H. C. BECK, and M. CONNOLLY. XIII+288 p. Cambridge, University Press, 1931. ISIS

Reviewed in *Nature*, 128, 1019-21, 1931.

Regnault, Félix. Les races humaines préhistoriques n'étaient point stéatopyges. *Revue scientifique*, 70, 145-49, 1932. ISIS

40. — ETHNOLOGY (*primitive and popular science*)

Besson, Maurice. Le totémisme. 80 p., 60 pl. Paris, RIEDER, 1929. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 140-41, 1930.

Descamps, Paul. Les causes de l'exogamie et de l'endogamie. Bruxelles, *Rev. de l'Institut de Sociologie*, 7, No. 1, 1927. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 107-08, 1930.

Descamps, Paul. Les origines du totémisme collectif. Bruxelles, *Rev. de l'Institut de Sociologie*, 7, No. 4, 1927. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 108-09, 1930.

Deursen, Arie Van. Der Heilbringer, eine ethnologische Studie, über den Heilbringer bei den Nord-Amerikanischen Indianern. 395 p. Groningen, 1931. ISIS

Reviewed by V. LAROCK, *Revue de l'Histoire des Religions*, 104, 457-61, 1931.

Fortune, Reo Franklin. Sorcerers of Dobu. The social anthropology of the Dobu islanders of the western Pacific. Introduction by B. MALINOWSKI. Pl., map. London, ROUTLEDGE, 1932. ISIS

Leyder, Jean. Conceptions des Bwaka sur les astres (Ubangi). *Revue de l'Université de Bruxelles*, 37, 150-60, 1931-32. ISIS

Malinowski, Bronislaw. The sexual life of savages in North-western Melanesia. An ethnographic account of courtship, marriage, and family life among the natives of the Trobriand Islands, British New Guinea. Preface by HAVELOCK ELLIS. Third edition, with special foreword. LII+506 p., 96 pl., fig. London, ROUTLEDGE, 1932. ISIS

1929 edition reviewed by GEORGE SARTON, *Isis*, 13, 395-97, 1930.

Michelson, Truman. The narrative of a southern Cheyenne woman. 13 p. (*Smithsonian miscellaneous collections*, vol. 87, No. 5.) Washington, Smithsonian Institution, 1932. ISIS

Rydh, Hanna. On symbolism in mortuary ceramics. *Bull. of the Museum of Far Eastern Antiquity*, 71-120, 11 pl., 62 fig., Stockholm, 1929. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 127-28, 1930.

(**Temple.**) Sir **Richard Temple**, Bt., 1850-1931. 10 p. (From the *Proceedings of the British Academy*, 17.) Oxford, University Press, 1931. ISIS

41. — SUPERSTITION AND OCCULTISM

Becker, E. T. Erfolg der Wünschelrute bei den Wiederherstellungsarbeiten des Wehres in Avanhandava. *Archiv zur Klärung der Wünschelrutenfrage*, 1, 43-47, 6 fig., 1931. ISIS

Dessoir, Max. Vom Jenseits der Seele. Die Geheimwissenschaften in kritischer Beleuchtung. 6., neu bearbeitete Auflage. XIV+562 p., 4 pl. Stuttgart, ENKE, 1931. ISIS

Reviewed by Graf CARL V. KLINCKOWSTROEM, *Isis*, 17, 453, 1932.

Graf, Arturo. The story of the devil. Translated from the Italian by EDWARD NOBLE STONE. With notes by the translator. XIV+ 296 p. London, MACMILLAN, 1931. ISIS

Kranz, Walter. Wünschelrutenversuche am Gebirgsbau der Blattgebiete Leonberg und Weissach NW Stuttgart, mit Beitrag zur Baugrundgeologie. *Archiv zur Klärung der Wünschelrutenfrage*, 1, 3-42, 8 fig., 2 pl., 1931. ISIS

Mager, Henri. Water diviners and their methods. Translated from the fourth edition of " Les sourciers et leurs procédés," by A. H. BELL. XI+308 p., 8 pl. London, BELL, 1931. ISIS

Maltzahn, Rud. Frhr. v.; Marquardt, E. Professor ZUNKER und die Wünschelrute. *Archiv zur Klärung der Wünschelrutenfrage*, 1, 48-58, 3 fig., 1931. ISIS

Rudwin, Maximilian Josef. The devil in legend and literature. XI+354 p. Chicago, Open Court, 1931. ISIS

Wirth, Oswald. Les mystères de l'Art Royal ; étude sur le ritualisme initiatique des confraternités constructives. 244 p., ill. Paris, NOURRY, 1932. ISIS

L'Art Royal est ainsi appelé en souvenir du fils de David; depuis le XVIII[e] siècle, le terme est devenu synonyme de franc-maçonnerie. Celle-ci « comporte des *mystères* d'ordre religieux qui sont ceux du véritable Art Royal ». L'auteur expose ici, pour ceux qui sont *initiables* à ces mystères, la signification du symbolisme maçonnique, où il trouve des résonnances pythagoriciennes et médiévales. L. G.

(Wünschelrute). Der Verlauf einer Wünschelruten-Bohrung 1918-1920. Aus den Akten des Bayer. Landesamtes für Wasserversorgung. *Archiv zur Klärung der Wünschelrutenfrage*, 1, 59-68, 1 fig., 1931. ISIS

"Ein Beispiel, wie Rutengänger und ihre 'Sachverständigen' zuweilen ernstliche Unternehmer durch haltlose Versprechungen verhindern, sich vor der Bohrung ein einwandfreies Urteil über das wahrscheinliche Ergebnis auf Grund wissenschaftlicher Überlegungen zu verschaffen, sie dafür aber in Unkosten stürzen, ohne irgendein brauchbares Ergebnis zu liefern."

43. — SOCIOLOGY, JURISPRUDENCE AND POSITIVE POLITY

Descamps, Paul. La signification sociale des gynécolatries. Paris, *Rev. intern. de Sociologie*, 36, 10 p., 1928. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 110, 1930.

Descamps, Paul. Recherches sur l'état social originel. Bruxelles, *Rev. de l'Institut de Sociologie*, 8, 1928. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 110, 1930.

Valdour, Jacques. Les méthodes en science sociale. Etude historique et critique. VIII+316 p. Paris, ROUSSEAU, 1927. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 133, 1930.

44. — HISTORY OF CIVILIZATION

(General history, historical methods, biography and chronology)

Counson, Albert. La civilisation ; action de la science sur la foi. 192 p. Paris, ALCAN, 1929. ISIS

Animé d'une foi profonde dans l'avenir de la civilisation : « la barbarie a vécu, la civilisation commence », l'auteur de ces essais sur « la matière, le mouvement, la vie », d'une part, sur « la liberté, l'égalité, la fraternité », d'autre part, trouve dans l'histoire des sciences les raisons profondes de son optimisme. L. G.

Dutcher, George Matthew ; Shipman, Henry Robinson ; Fay, Sidney Bradshaw ; Shearer, Augustus Hunt ; Allison, William Henry (ed.) A guide to historical literature. XXVIII+1222 p. New York, MACMILLAN, 1931. ISIS

Reviewed by JOSEPH MAYER, *Isis*, 17, 453-64, 1932.

Gann, Thomas ; Thompson, J. Eric. The history of the Maya from the earliest times to the present day. X+264 p. New York, SCRIBNERS, 1931. ISIS

Hernshaw, F. J. C. History as a science. *Scientia*, 51, 228-36, 1932. ISIS

Jullian, Camille. Au seuil de notre histoire. Tome 3. 215 p. Paris, BOIVIN, 1931 (18 fr.). ISIS

Ce tome III termine la publication en volumes de la synthèse de vingt-cinq années d'enseignement au Collège de France (Tomes I et II, *Isis*, 17, 603). Sommaire : Au sujet de l'histoire-bataille; La valeur morale de l'histoire; Les premiers temps de la Gaule romaine; La joie de vivre; Les temps de la Gaule romaine; La valeur morale des choses; La vertu du Christianisme; La faillite d'un régime; Les forces éternelles de la Gaule. L. S.

Kidder, A. V. Annual report of the Division of historical research. Section of United States History. *Carnegie Institution of Washington, Year book* no. 30, for the year 1930-31, p. 142-58, 1931. ISIS

Lacroix, Alfred. Figures de savants. T. 1, x+326 p., 32 pl.; T. 2, 360 p., 25 pl. Paris, GAUTHIER-VILLARS, 1932. ISIS

Notices, avec portraits et reproductions d'autographes, sur N. DESMAREST, G. DUHAMEL, B. DE VILLIERS, A. DUFRÉNOY, H. STE-CLAIRE DEVILLE, E. HEBERT, E. MALLARD, P. HAUTEFEUILLE, E. MUNIER-CHALMAS, E. HAUG, D. DOLOMIEU, R. J. HAÜY, F. S. BEUDANT, A. DESCLOIZEAUX, BORY DE ST. VINCENT, A. LÉVY, J. L. DE BOURNON, A. GRANDIDIER, A. MILNE-EDWARDS, J. B. BOUSSINGAULT, A. DAMOUR, A. DE LAPPARENT, A. DE GRAMMONT, A. MICHEL-LÉVY, F. FOUQUÉ. Discours prononcés à des cérémonies commémoratives de J. DE LALANDE, L. PASTEUR, A. VULPIAN, M. BERTHELOT.

L. G.

Mauriac, Pierre. Quelques littérateurs parmi les savants. *Revue hebdomadaire*, 40, 395-418, 1931. ISIS

MONTESQUIEU, DIDEROT, J. J. ROUSSEAU, GOETHE, PAUL VALÉRY et PAUL CLAUDEL dans leurs fugues scientifiques.

J. P.

45. — HISTORY OF ART

(*Art and science, Iconography. Arts and crafts*)

Farmer, Henry George. The organ of the ancients. From eastern sources (Hebrew, Syriac, and Arabic). Foreword by F. W. GALPIN. XXIII+185 p., 16 fig. London, REEVES, 1931. ISIS

Reviewed by GEORGE SARTON, *Isis*, 17, 278-82, 1932.

Sachs, Curt. Geist und Werden der Musikinstrumente. XII+284 p., 48 pl. Berlin, REIMER, 1929. ISIS

Reviewed by J. NIPPGEN, *l'Ethnographie*, 128-29, 1930.

46. — HISTORY OF LANGUAGE, WRITING AND LITERATURE

Brunot, Ferdinand. Histoire de la langue française des origines à 1900. T. VI. Le XVIII[e] siècle. Première partie. Le mouvement des idées et les vocabulaires techniques. Fascicule 2. La langue des sciences, par MAX FUCHS; la langue des arts. 340 p. Paris, COLIN, 1930. ISIS

Reviewed by L. GUINET, *Isis*, 17, 431-33, 1932.

Dauzat, Albert. Les atlas linguistiques et leurs progrès récents. Paris, *La Nature*, 4-7, 1 map, 1929. ISIS

48. — HISTORY OF PHILOSOPHY

(See also above, 18. Philosophy of science)

Bréhier, Emile. Histoire de la philosophie. T. II, fasc. 3. Le XIX^e siècle. Période des systèmes (1800-1850). 340 p., Paris, ALCAN, 1932. ISIS

« De 1800 à 1850, une extraordinaire floraison de doctrines amples et constructives, qui prétendent révéler le secret de la nature et de l'histoire et faire connaître à l'homme la loi de sa destinée, individuelle et sociale; les doctrines catholiques que DE MAISTRE et DE BONALD construisent en réaction contre le XVIII^e siècle, la psychologie de MAINE DE BIRAN qui s'achève en des vues religieuses, les grandes métaphysiques allemandes post-kantiennes, celles de FICHTE, de SCHELLING, de HEGEL dont le spiritualisme de VICTOR COUSIN est une imitation, les doctrines sociales de SAINT-SIMON, de COMTE et de FOURIER, ont toutes en commun ce caractère d'annonce prophétique ou de révélation ». « Partout, l'idée d'un fatum historique, d'une loi immanente qui se joue des résistances, a remplacé la foi dans l'initiative raisonnable et réfléchie des volontés humaines; ce fatum, chacun, DE BONALD ou DE MAISTRE, comme AUGUSTE COMTE, SAINT-SIMON ou FOURIER, croit l'avoir découvert ». Bien entendu, ne sont oubliés ni LAMENAIS, DESTUTT DE TRACY, HAMILTON, ni SCHOPENHAUER, ni BALLANCHE, KIRKEGAARD, ni ROSMINI, GIOBERTI, MAZZINI, etc., etc. Comme dans les fascicules précédents (*Isis*, 9, 593; 11, 555; 14, 563; 15, 425), chaque chapitre est suivi d'une bibliographie courte, mais qui donne l'essentiel. L. G.

Lalande, André. Les illusions évolutionnistes. XII+466 p. (*Biblioth. de philosophie contemporaine*). Paris, ALCAN, 1930. ISIS

Nouvelle édition, revue et abrégée, de la thèse de doctorat de LALANDE, soutenue en 1899, sous le titre « L'idée directrice de la Dissolution, opposée à celle de l'Évolution, dans la méthode des sciences physiques et morales ». I. L'évolutionnisme; 2. L'involution dans les phénomènes physiques et biologiques (par involution, l'auteur entend « le processus inverse de celui qui fait pour l'évolutionniste, la loi du développement commun de la vie (y compris la vie de l'esprit) c'est-à-dire la production de touts organiques de plus en plus larges, de plus en plus forts dans la lutte, et de plus en plus rigoureusement différentiés »); 3. L'activité de l'esprit est involutive; 4. Évolution sociale ou involution?; 5. Dualisme de fait; 6. Conséquences de droit. L. G.

Regenbogen, Otto. Die Naturwissenschaft der Peripatetiker. *Scientia*, 50, 345-64, 1931; traduct. fr., *ibid.*, supplément, 133-41. ISIS

Ruyer, R. Esquisse d'une philosophie de la structure. 370 p. Paris, ALCAN, 1931. ISIS

L'auteur de cette thèse s'est proposé « de montrer que toutes les réalités si ' essentiellement ' différentes les unes des autres qu'elles paraissent, sont néanmoins toutes des formes, des mécanismes, et d'expliquer toutes les différences par des différences de structure dans l'espace ».

Snyder, Alice Dorothea. COLERIDGE on logic and learning. Selections from the unpublished manuscripts. XVII+169 p. New Haven, Yale Univ. Press, 1929. ISIS

Reviewed by FERDINAND TÖNNIES, *DLZ*, 3, 265-66, 1932.

VII. MEDICINE

50. — HISTORY, ORGANIZATION, AND PHILOSOPHY OF MEDICINE

Artelt, Walter. Arzt und Leibesübungen in Mittelalter und Renaissance. II. Renaissance. *Klinische Wochenschrift*, 10, 2092-96, 1931. ISIS

"In der Antike hatten die Leibesübungen, wie EDELSTEIN mit aller Deutlichkeit gezeigt hat, einen festen Rückhalt in der Medizin. Im Mittelalter waren die Leibesübungen untrennbar ebenso mit dem Rittertum verbunden wie mit dem Volkstum, unter wohlwollender Duldung durch die grösste kulturelle Macht des Mittelalters, die Kirche, und theoretischer Förderung durch die Medizin, die praktisch ebenfalls einer wohlwollenden Duldung gleichkam. In der Renaissance aber sind die Leibesübungen nicht mehr für wesentliche Schichten der Völker selbstverständlich und verbindlich; die Stellung der Medizin zu ihnen blieb auch jetzt alles in allem zu theoretisch, um ihnen ihre—theoretisch immer wieder bewiesene—Existenzberechtigung zu erhalten oder wiederzuerkämpfen. Es gibt kaum noch Leibesübungen im Jahrhundert des Dreissigjährigen Krieges. An dem neuen Aufschwung im Beginn des 18. Jahrhunderts nahm auch die Medizin tatkräftigen und erfolgreichen Anteil".

Artelt. Bericht über Verhandlungen der Deutschen Gesellschaft für Geschichte der Medizin und der Naturwissenschaften zu Königsberg, 7.-11. September 1931. *Janus*, 35, 106-14, 1931. ISIS

Diepgen, Paul. Alte und neue Romantik in der Medizin. *Klinische Wochenschrift*, 11, 28-34, 1932. ISIS

"Wer sich mit den Beziehungen der geistigen Bewegung, die man Romantik nennt, zur Medizin auseinandersetzen will, stösst schon deshalb auf Schwierigkeiten, weil es kaum möglich ist, sich in dem Wirrwarr der verschiedenen Formulierungen dieses Begriffes zurechtzufinden. Man hat sich aus der Verlegenheit geholfen, indem man unter den Romantikern keine Richtung, sondern eine Generation verstanden hat, eine Generation von in erster Linie deutschen Dichtern, Künstlern, Philosophen, Historikern, Naturforschern und Ärzten, die etwa im ersten Drittel des 19. Jahrhunderts auf der Höhe ihres Schaffens standen. Aber damit wäre uns nicht genützt. Gerade, dass wir auch heute noch von einer Romantik in der Medizin sprechen wollen und dürfen, beweist, dass wir den Begriff nicht nur auf eine bestimmte Zeitspanne von einigen Dezennien zu beziehen brauchen. Trägt nicht

jeder Mensch ein Stückchen Romantik im Herzen? Kann man ohne dieses irrationelle Etwas überhaupt ein guter Arzt und ein guter Medizinhistoriker sein?"

Janus. Central-Magazin für Geschichte und Literärgeschichte der Medicin, ärztliche Biographik, Epidemiographik, medicinische Geographie und Statistik. In Verbindung mit mehreren Gelehrten des In- und Auslandes hrsg. von H. BRETSCHNEIDER, A. W. E. TH. HENSCHEL, C. Fr. HEUSINGER, und J. G. THIERFELDER. 2 vols. Gotha, 1851-52. Reprinted, Leipzig, A. LORENTZ, 1931. ISIS

Reviewed by G. SARTON, *Isis*, 17, 283-84, 1932.

Janus. Zeitschrift für Geschichte und Literatur der Medicin im Verein mit L. CHOULANT, H. HAESER, J. F. C. HECKER, C. F. HEUSINGER, F. JAHN, J. C. MARX, J. ROSENBAUM u. A. hrsg. von A. W. E. TH. HENSCHEL. 3 vols. Breslau, 1846-48. Reprinted, Leipzig, A. LORENTZ, 1931. ISIS

Reviewed by G. SARTON, *Isis*, 17, 283-84, 1932.

Mazzini, Giuseppe. I medici e la medicina del Perù Incaico. *Archeion*, 13, 408-23, 1931. ISIS

Revue de nos connaissances sur les pratiques médicales des Incas.

Power, Sir D'Arcy. The foundations of medical history. x+182 p., pl., port. (Johns Hopkins University, Institute of the History of Medicine). Baltimore, WILLIAMS and WILKINS, 1931. ISIS

Szumowski, Wladislas. Sur la nécessité de rendre l'étude de l'histoire de la médecine obligatoire dans les universités. Rapport présenté au VIII[e] Congrès International d'Histoire de la Médecine à Rome le 26 septembre 1930. *Atti dell' VIII-o Congresso Internazionale di Storia della Medicina*, 13 p., Pisa, 1931. ISIS

Warthin, Alfred Scott. The physician of the dance of death. A historical study of the evolution of the dance of death mythus in art. XVI+142 p., frontispiece, 92 figs. New York, HOEBER, 1931. ISIS

Reviewed by CHARLES A. KOFOID, *Isis*, 17, 282-83, 1932.

51. — EPIDEMIOLOGY, HISTORY OF SPECIAL DISEASES. PUBLIC HEALTH AND SOCIAL MEDICINE

Barger, George. Ergot and ergotism. A monograph based on the

Dohme lectures delivered in Johns Hopkins University, Baltimore. XVI+279 p. London, GURNEY and JACKSON, 1931. ISIS

Carter, Henry Rose. Yellow fever. An epidemiological and historical study of its place of origin. Edited by LAURA ARMISTEAD CARTER and WADE HAMPTON FROST. XII+308 p., 5 figs. Baltimore, WILLIAMS & WILKINS, 1931. ISIS

Reviewed by C. A. KOFOID, *Isis*, 17, 464-66, 1932.

Mazzini, Giuseppe. Maternità e infanzia nel Perù precolombiano. Estratto dal volume pubblicato in onore del RICCARDO SIMONINI. 9 p. Modena, Immacolata Concezione, 1932. ISIS

52. — HISTORY OF HOSPITALS AND OF MEDICAL TEACHING

(Maryland, Medical Library.) Celebration of the centennial of the Library of the Medical and Chirurgical Faculty of the State of Maryland, 1830-1930. X+78 p. 34 pl. Baltimore, 1931. ISIS

Reviewed by CHARLES A. KOFOID, *Isis*, 17, 466-67, 1932.

Masson, Louis. Le vieil amphithéâtre d'anatomie de Bologne. *Aesculape*, 28, 275-80, 1931. ISIS

53. — PHARMACY. PHARMACOLOGY. TOXICOLOGY

Dominguez, Juan A. Contribuciones a la materia médica Argentina. (Primera contribucion) XXIII+433 p. (*Trabajos del Instituto de Botánica y Farmacologia*, no. 44). Buenos Aires, PEUSER, 1928. ISIS

Prefaced by an historical account of 79 pages, in which the contributions of the significant explorers and botanists especially are discussed. There is also included a concise account of therapy in the pre-Columbian period and during the Conquest. C. D. L.

Rosemont, L. Reuter de. Histoire de la pharmacie. T. I. De l'antiquité au XVI^e^ siècle. 606 p., ill. Paris, PEYRONNET, 1931. ISIS

Vaste compilation hétéroclyte, écrite dans un style étrange qui en rend la lecture singulièrement pénible. L'illustration n'a le plus souvent aucun rapport avec le texte dans lequel elle s'insère : par exemple, les chapitres, très courts, relatifs à la pharmacie chez les Israélites et les Phéniciens se terminent par des images de pots de pharmacie du XVI^e^ siècle; celui qui traite de la pharmacie chez les Égyptiens est orné de deux portraits : GALIEN et PARACELSE (sans renvoi à ce dernier dans les pages où il est traité de PARA-

CELSE), et de deux « frontispice d'un livre ancien » sans aucune identification. Ces deux images figurent en tête d'une copie du XVI[e] siècle de l'Antidotaire de NICOLAS MYREPSOS (Cod. gr. Paris 2243). L. G.

VIII. EDUCATION

(The methods of accumulating, imparting and diffusing knowledge)

54. — EDUCATION (*Generalities, methods, colleges, universities*)

Cattell, J. McKeen. Leaders in education. A biographical directory, edited by J. MCKEEN CATTELL. VI+1037 p. New York, Science Press, 1932. ISIS

This useful work contains over 11000 biographical sketches of those in North America "who have done the most to advance education, whether by teaching, administration, publication or research." Each entry begins with the full name, title and mail address. This is followed by the place and date of birth with the names of educational institutions attended and the degrees awarded with dates. Positions held are given in detail. Honorary, temporary and minor positions are then recorded, followed by membership in educational societies. The sketch concludes with a brief statement of the character of activities and publications.

The general style of the work is similar to that of *American Men of Science* of which the fifth edition, with about 20,000 sketches, is to appear early in 1933. Many names of individuals listed in the fourth edition of this work are also to be found in *Leaders of Education*. Doctor CATTELL is to be congratulated on the publication of this further very useful work, well conceived and edited. R. C. A.

55. — ACADEMIES, SOCIETIES, CONGRESSES. NATIONAL AND INTERNATIONAL ORGANIZATION OF SCIENCE

(*Societies and congresses devoted to particular sciences are classified under those sciences. For the internal organization of science*—Isis, 1, 195—*see section* 17)

(Comité international des sciences historiques). Le comité international des sciences historiques. Son activité, ses congrès, son organisation, ses collaborateurs. Washington, 1932. ISIS

L'activité du Comité international des sciences historiques. L'organisation scientifique des congrès futurs, particulièrement du congrès de 1933. Organisation du Comité international des sciences historiques. Liste des membres, collaborateurs et correspondants.

Wallerant, Fred. La société française de minéralogie de 1878 à 1928. *Bul. Soc. franç. minéralogie*, 53, 3-21, portr., 1930. ISIS

IX

59. — ERRATA. Series 25.

(For previous errata see ISIS, 18, 531)

Vol. 1, 311, l. 5 Read " MATHIAS " instead of " Matthies ".
Vol. 5, 291, l. 5 from bottom. Read "LEBESGUE" instead of "Lebesque".
Vol. 17, 209, l. 3 from bottom : Dr. SARTON sailed on July 26 (1931), not from Quebec but from Boston.
286, l. 16 ; 430, l. 1, 3, 23, 24, 26 ; p. 431, l. 3, Read ḤAZM, not Ḥazim.
568, last line, read Dulcarnain.

SARTON's *Introduction to the History of Science*, vol. 2.
p. 216, l. 5 from bottom. Read " Muslime," instead of " Mulime."
436, l. 15. Read Amplonianus instead of Amplianus.
594, l. 24. Read dargebracht instead of dargestellt.
818. First line after table. Read " establishes " instead of " places."
832, l. 11 from bottom. Read Bergstraesser, instead of Berstraesser.
870, l. 23. Kohlensäure (Fehler schon bei Wiedemann !)
899, l. 26 from bottom. Read alchimiae instead of alchimae.
949, l. 26. Read Entomologie instead of Zoologie.
1041, l. 10-11. Read Glas instead of Glass.
1088, l. 9 from bottom. Read samt dem.

A few other misprints are not mentioned in these errata because they are too obvious to cause any error or confusion. I wish to express my thankfulness to the readers who take the trouble to make the above-mentioned corrections in their set of *Isis* and the *Introduction*. I would advise them, after having accomplished that little task, to write their initials near mine at the bottom of this note, thus to indicate that these and the previous errata have been taken into account. G. S.

These and the previous errata have been corrected by...

Index of Authors Included in the Thirty-fifth Bibliography

The Roman figures refer to centuries ; the Arabic figures, to the sections of Parts II and III, which are numbered consecutively from 1 to 59. This index will enable one to find more easily the papers analyzed in the present bibliography, and also to see at a glance what each writer is doing.

August 1932. FRANCES SIEGEL.

A

Abb, G., XIX (2) E.
Abū Muḥ. ʿAlī b. Ḥazm al-Andalusi, 14.
Adams, C. W., XVII (2) B.
(Alcoholic distillation), XII (2).
Alfonso X el Sabio, XIII (2).
ʿAlī, Z., 14.
Allen, E. T., XX B.
Allison, W. H., 44.
Alphandéry, P., 6.
ʿArabī, ibn, XIII (1).
Archibald, R. C., XX A.
Armstrong, E., XX B.
Arrighi, G., XVIII (1) A.
Artelt, W., 50.

B

Bailey, S. I., 23.
Baker, J. N. L., 31.
Baldino, M., XVIII (2) C.
Barger, G., 51.
Bartholomew of Salerno, XII (1).
Becker, E. T., 41.
Bell, Sir C., 8.
Bernhard, H., XIX (2) B.
Berr, H., XX E.
Besson, M., 40.
Birkenmajer, A., XV (1).
Bodewig, E., XIII (2).
Bogaert, E. W., 26.
Bologa, V. L., 3.
Bontius, J., XVII (1) D.
Bosmans, H., XVII (1) A, XVII (2) A.
Boutaric, A., 25.
Bréhier, E., 48.
Breuil, H., 35.
(British Museum of Natural Hist.), XX C.
Browne, C. A., XX C.
Bruhat, G., 23.
Brunet, P., XVIII (1) B.
Brunot, F., 46.
Buhl, A., XX A.
Burr, A. C., 24.

C

Campbell, A. M., XIV (1).
Capitan, L., 39.
(Carnegie Institution), 16.

Carter, H. R., 51.
Cattell, J. M., 54.
Cesari, C., XIX (2) B.
Chaine, J., XIX (1) C.
Ch'ang-Ch'un, XIII (1).
Cheikho, L., 6, 14.
Ch'iu Chang-ch'un, XIII (1).
Chu I-chung, XII (1).
Cistercian rule, XII (1).
Clemen, C., XX E.
(Comité int. des sciences hist.), 55.
(Compass), XIII (1).
Compton, P., XIX (2) D.
Counson, A., 44.
Cramp, W., XIX (1) B.
Cromez, G., 26.
Crommelin, C. A., XVII (2) B.
Crum, R. B., 18.

D

Dains, F. B., XX C.
Dallari, U., XIV (1).
Dampier, W., XVII (2) C.
Dasgupta, S., 9.
Datta, B., 9.
Dauzat, A., 46.
Deffontaines, P., XX C.
De Graaff, N., XVII (2) C.
Descamps, P., 40, 43.
Dessoir, M., 41.
Deursen, A. Van, 40.
Devaux, P., 18.
Diepgen, P., 50.
(Distillation), XII (1).
Dobbin, L., XVI (1) C.
Dold, P. A., 6.
Dominguez, J. A., 53.
Dorveaux, P., XVII (2) D, XIX (1) E.
Doublet, E., 23.
Drewitt, F. D., XVIII (2) D.
Driesch, H., XX C.
Duncan, J. G., 12.
Dussaud, R., 8.
Dutcher, G. M., 44.

E

Eddington, A. S., 24.
Ekkehard of Aura, XII (1).
Essig, E. O., 29.
Evans, Sir A., 4.
(Ewald), XIX (2) E.

F

Faraday, XIX (1) B.
Faraj b. Salīm, XIII (2).
Farmer, H. G., 45.
Faucci, U., XVII (2) D.
Fay, S. B., 44.
Ferguson, J., XIII (1), XVI (1) E.
Foakes-Jackson, F. J., I (2).
Forbes, G. S., XX B.
Fortune, R. F., 40.
Friedman, H. B., XIX (1) B.

G

Gann, T., 44.
Geber, XIII (2).
Gennaro, S. di, XVII (1) A.
Gessler, J., XIV (1).
Gordon, H. L., 12.
Gordon, N. E., XX B.
Gottheil, R., 14.
Gough, J. W., XVII (2) B.
Gowen, H. H., 9.
Graf, A., 41.
Greek (fire), VII (2).
Grenard, F., XVI (1) E.
Gunn, J. A., XX D.

H

Hadfield, Sir R. A., XIX (1) B.

Hagen, J. G., 23.
Hale, G. E., 23.
Hale, H., XX B.
Halphen, L., 6.
Handelsman, M., 6.
al-Ḥarīrī, XII (1).
Hartner, W., 14.
Heape, W., 29.
Heischkel, E., XVIII (1) D.
Helderman, L. C., XVIII (2) E.
Hellman, C. D., XVIII (1) A.
Helmholtz, H. v., 20.
Hernshaw, F. J. C., 44.
Heuten, G., 2.
Hilbert, D., 19.
Hildegard, XII (2).
(Hist. of Science), 16.
Homo, L., 5.
Honeywell, R. J., XVIII (2) E.
Howard, L. O., 29.
Hrozný, B., 8.
Hudson, G. F., 10.
Humbert, P., 23.
Hummel, A. W., 8.
Husserl, E. G., XVII (1) E.

I

Iltis, H., XIX (2) C.
Izzeddine, C., 14.

J

(Janus), 50.
Janssens, E., 37.
Jeans, Sir J. H., 18.
Joachim de Flore, XII (2).
Jørgensen, J., 19.
Jordanus Nemorarius, XIII (1).
Jullian, C., 44.

K

Kaisin, F., XX C.
Kammerer, A., 8.
Kantorowicz, E., XIII (1).
Karpinski, L. C., 31.
Katō, G., 11.
Kendall, J., XX B.
Khān, 9.
al-Khāzinī, XII (1).
Kidder, A. V., 44.
Koht, H., 6.
Koppelmann, Dr., 19.
Kranz, W., 41.

L

Lacroix, A., 44.
Laird Clowes, G. S., 26.
Lalande, A., 48.
Langevin, P., 16.
Larsen, H., 6.
Leake, C. D., XX D.
Leakey, L. S. B., 39.
Lefebvre des Noettes, Ct., 6, 26.
Lenzen, V. F., III (2) B. C.
Leroy, O., XVII (1) E.
Lévy-Bruhl, L., 37.
Leyder, J., 40.
Lichtenstein, L., 18.
Lidell, H. G., 4.
Lippmann, E. O. v., XVIII (1) B, 2, 25.
Lodge, Sir O., XIX (2) B.
Loria, G., 20.
Luquet, G. H., 20.

M

Madan, F., XVII (2) E.
Mager, H., 41.
Magoun, F., 26.
Malinowski, B., 40.
Maltzahn, R. F. v., 41.
Manley, R. M., 24.
Manquat, M., IV (2) B. C.
Marc the Greek, XIII (2).

Marcolongo, R., XV L, 20.
Margolis, M. L., 12.
Marquardt, E., 41.
Marx, A., 12.
(Maryland, Med. Library), 52.
Masson, L., 52.
Maudslay, A. P., XIX (2) C.
Mauriac, P., 44.
Maynard, K., 16.
Mazzini, G., 50, 51.
McKee, R. H., XX B.
Meyerhof, M., 14.
Meyerson, E., 16, 19.
Michelson, T., 40.
Miller, B., 14.
Mirone, G., 5.
Mitrovitch, R., XVII (1) A.
Montmasson, J.-M., 37.
Morison, S., XVII (2) E.

N

Natucci, A., 17.
Needham, J., 27.
Nero, I (2).
Neugebauer, O., 3.
Neville, E. H., XVIII (1) A.
Newell, L. C., XX B.
Newman, H. H., 27.
Nicolle, C., 27.
Nierenstein, M., XVII (2) B.
Nieuwenhuis, A. W., 27.
Nilsson, M. P., 4.
Northrop, F. S. C., 18.

O

Omstead, A. T., 8.

P

Padoa, A., 20.
Palacios, M. A., 14.
Parsons, C. L., XX B.
Partington, J. R., 10.
Paul, J. H., XX C.
Peet, T. E., 2.
Pelseneer, J., XVII (1) C, XVIII (1) B, 20.
Perrey, E., 6.
Piaggio, H. T. H., XX A.
Picard, E., XIX (2) B, 16.
Pickman, E. M., XVII (1) E.
Pina, L. de, 35.
Pincherle, B., XIX (1) D.
Piney, A., 27.
Pirenne, H., 6.
Planck, M., 24.
Pogo, A., 2.
Pommier, J., XIX (1) E.
Pottier, E., 1.
Power, Sir d'A., 50.
Powicke, F. M., 6.
Pusey, W. A., XIX (2) D.

R

(Radio), 26.
Regenbogen, O., 48.
Regnault, F., 39.
Renaud, H. P. J., XIX (2) E.
Renaudet, A., 6.
Ribeiro dos Santos, A., 20.
Rickert, E., XIV (2).
Ridgeway, Sir W., 4.
Robert of Chester, XII (1).
Rome, A., XVII (1) E., 23.
Rosemont, L. R. de, 52.
Rosenfeld, L., XVII (2). B.
Rougier, L., XVII (2) B.
Roule, L., XVIII (2) C.
Rubruquis, XIII (2).
Rudwin, M. J., 41.
Rudy, H., XVI (1) D.
Ibn Rushd, XII (2).
Ruska, J., 6.

Ruyer, R., 48.
Rydh, H., 40.

S

Sachs, C., 45.
Sa'dī, XIII (2).
Santos, V., XVIII (2) C.
Sarton, G., XVIII (1) B, XIX (1) B, 16.
Saussure, L. de, 10.
Scalinci, N., XII (2).
Scardapane, N. M., 20.
Schreiber, E. W., XX A.
Schub, P., XV (1).
Schudt, L., 5.
Schuyler, H., XIX (2) B.
Scott, R., 4.
Scudder, V. D., XIII (1).
Sengupta, P. C., VII (1).
Shearer, A. H., 44.
Shipman, H. R., 44.
Shryock, J., 10.
Smith, E. F., XX B.
Snyder, A. D., 48.
Sprengling, M., 8.
Staehle, K., I (1).
Stawell, F. M., 4.
Straker, E., 26.
Streeter, G. L., 27.
Struve, O., XIX (2) B.
Studnička, F. K., XIX (1) C.
Szumowski, W., 50.

T

Taggart, W. T., XX B.
Tanfani, G., XVI (1) E.
Taylor, E. G. R., XVI (2) C.
Teilhard de Chardin, P., 35.
Temple, Sir R., 40.
Testi, G., 26.
Thomas Aquinas, XIII (2).
Thomas, B., 14.
Thompson, J. E., 44.
Tracy, H. C., 27.
Tropfke, J., XVII (1) A.
Tusser, T., XVI (2) C.

U

Uṣaibi'a, ibn abī, XIII (1).

V

Valdour, J., 43.
Vallée, A., XVIII (1) D.
Vallicrosa, J. M., 23.
Vallisnieri, A., 29.
Van Hecke, A., XX B.
Verlaine, L., 37.
Villamil, R. de, XVII (2) A.
Vowles, H. P., 26.

W

Walden, P., 25.
Waley, A., 10.
Wallerant, F., 55.
Warthin, A. S., 50.
Webb, C. C. J., XII (2).
Weeks, M. E., 25.
Weigall, A., I (2).
Welborn, M. C., 20.
Wenstrom, W. H., XX B.
Weulersse, G., XVIII (1) E.
Whitaker-Wilson, C., XVII (2) B.
White, A. M., XIX (1) B.
White, G., XVIII (1) C.
Wirth, O., 41.
Woodworth, R. S., 37.
(Wünschelrute), 41.

Y

Yamamoto, I, 11.
(Yoga), 9.

Z

Zeiss, H., XIX (2) C.
Zeitlin, S., I (2).